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# ECONOMIC EVALUATION OF THE PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

ENERGY RESOURCES COMPANY, INCORPORATED

PREPARED FOR
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OCTOBER 1975

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# ECONOMIC EVALUATION OF THE PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

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WASHINGTON, D.C.

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16. ABSTRACT

An economic evaluation was performed of the Proposed Interim Primary Drinking Water Regulations as published in the March 14, 1975, Federal Register. The results of this study indicate that the annual costs for water monitoring for community system would be between \$22 and \$43 million, while the costs for water monitoring for non-community systems would be between \$47 million and \$92 million if the proposed regulations were adopted. A cost of between \$1.1 billion and \$1.8 billion would be required to build treatment facilities to remove contaminants from the nation's drinking waters. It would cost an additional \$282 million per year to operate and maintain the required treatment plants. The annual per capita costs for those systems which would require treatment would range from \$244 for a system serving 25 people and treating for heavy metal removal to \$0.25 per year for systems serving over 100,000 people requiring disinfection. A constraint analysis examined the broad areas of chemicals and supplies, manpower, laboratories and engineering and construction services.

17. KEY WORDS AND DOCUMENT ANALYSIS

| a. DESCRIPTORS | b. IDENTIFIERS/OPEN ENDED TERMS | c. COSATI Field/Group |
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# CHAPTER ONE

## EXECUTIVE SUMMARY

### 1.0 Safe Drinking Water Act of 1974

The purpose of the Safe Drinking Water Act is to assure that water supply systems serving the public meet minimum national standards for the protection of public health. To achieve this objective the Congress authorized the Environmental Protection Agency to promulgate national drinking water regulations. In addition, the Act provides a mechanism for the individual states to assume the primary responsibility for enforcing the regulations by providing general supervisory aid to the public water systems and inspecting public water supplies.

The objective of the legislation is to establish standards which will provide for safe drinking water supplies throughout the United States. Prior to passage of the Act, the Environmental Protection Agency was authorized to prescribe Federal drinking water regulations only for water supplies used by interstate carriers. Furthermore, these regulations could only be enforced with respect to contaminants capable of causing communicable disease. In contrast, the Safe Drinking Water Act authorized the Environmental Protection Agency to establish (1) Federal regulations for the protection of all public water systems from all harmful contaminants; and (2) a joint Federal-State system to assure compliance with these regulations and to protect underground sources of drinking water.

### 1.1 Proposed National Interim Primary Drinking Water Regulations

The EPA published its Proposed National Interim Primary Drinking Water Regulations in the Federal Register, March 14, 1975. The major provisions of the Proposed Interim Primary Drinking Water Regulations are:

1. Establishment of maximum contaminant levels for certain inorganic, organic, and biological contaminants, and establishment of maximum turbidity levels;

2. Establishment of monitoring frequencies;
3. Establishment of a methodology to notify consumers of variances, exemptions, and non-compliance with regulations;
4. Establishment of reporting requirements for systems failing to comply with the regulations.

## 1.2 Public Water Systems

### 1.2.1 Background and Definitions

The Interim Primary Drinking Water Regulations define the term "public water system" as a system for the provision to the public of piped water for human consumption, if such a system has at least 15 service connections or regularly serves an average of at least 25 individuals daily at least three months out of the year. The term "community water system" is defined as a public water system which serves a population of which 70 percent or greater are residents. There are approximately 40,000 community water supply systems listed in the EPA Public Water Supply Inventory at the present time. For the purposes of this analysis, the EPA inventory is considered to be representative of the nation's community water systems in regard to important variables including population served, treatment facilities presently used, and source of water. Table 1-1 shows the distribution of community water systems by population served. Systems may obtain their water either from surface or ground sources or can purchase water from other producers. Generally, most small systems use ground sources while larger systems tend to use surface sources.

The percentage of systems presently employing the various treatment processes is presented in Table 1-2.

The available data indicate that the regional distribution of production is proportional to the regional distribution of population. Sixty-eight percent of the systems serve 1,000 or fewer people and account for only 2 percent of the water produced by community water systems, while 1 percent of the systems serving the largest populations account for 62 percent of the total production.

## TABLE 1-1

## DISTRIBUTION OF COMMUNITY WATER SYSTEMS

| POPULATION SERVED BY SYSTEM | NUMBER OF WATER SYSTEMS | TOTAL POPULATION (000's) | PERCENT OF TOTAL POPULATION |
|---|---|---|---|
| 25-99 | 7,008 | 420 | 0.2 |
| 100-9,999 | 30,150 | 36,816 | 20.8 |
| 10,000-99,999 | 2,599 | 61,423 | 34.6 |
| ≥100,000 | 243 | 78,800 | 44.4 |
| TOTAL | 40,000 | 177,459 | 100.0 |

Source: EPA Inventory of Public Water Systems, July 1975.

## TABLE 1-2

## TREATMENT PROCESSES EMPLOYED BY COMMUNITY WATER SYSTEMS[a]

| TREATMENT | EPA INVENTORY (%) |
|---|---|
| Aeration | 6.6 |
| Prechlorination | 7.8 |
| Coagulation | 11.3 |
| Sedimentation | 8.9 |
| Filtration | 12.8 |
| Softening | 4.9 |
| Taste and Odor Control | 3.4 |
| Iron Removal | 5.7 |
| Ammoniation | 0.9 |
| Fluoride Adjustment | 8.5 |
| Disinfection | 35.2 |

[a] Percentages do not total 100 percent since many systems have multiple treatments or no treatment.

Source: EPA Inventory of Public Water Systems, July 1975.

Of the approximately 40,000 community systems presently supplying water, the data indicate that 58 percent are publicly owned and that 42 percent are private, investor-owned. Eighty-eight percent of total production is from publicly-owned plants, with private plants contributing only about 12 percent.

It is estimated that there are approximately 200,000 public non-community water systems. This category includes systems at schools and industries as well as systems found at service stations, motels, restaurants, rest areas, campgrounds, state parks, beaches, national parks, national forests, dams, reservoirs, and other locations frequented by the travelling public. Since data on these systems are very sparse, only rough cost estimates can be made.

### 1.2.2 The Water Supply Industry

The water supply industry, as previously defined, includes only those systems which maintain facilities to supply water primarily for residential, commercial, industrial and municipal use. An approximate allocation of water supplied by water systems to various categories of users is shown in Table 1-3. Approximately 63 percent of the total water delivered is used for residential purposes.

TABLE 1-3

COMMUNITY WATER SUPPLY USE BY CATEGORY

| TYPE OF USE | PERCENTAGE OF TOTAL |
|---|---|
| Residential | 63 |
| Commercial | 11 |
| Industrial | 21 |
| Municipal | 5 |
| TOTAL | 100 |

Source: U.S. Geological Survey estimates, 1972.

The price consumers pay for water is determined, in general, by costs the utility incurs for monitoring, treatment, storage, and distribution. However, some publicly-owned water systems may have their costs and revenues conglomerated with the costs of other municipal services, with the result that the water bill paid by the consumer may not completely reflect the status of the water system alone. The type of rate structure used by a particular water system varies from system to system, and may also be different for various user classes within the same system.

There are four basic types of rate structures in use in varying degrees around the country. Systems using a "normal block" structure charge lower unit costs to those customers which use higher volumes of water. "Inverted block" structure systems charge higher unit costs to customers who use higher volumes of water. Under a "flat" rate structure there is one single charge per unit for all customers, regardless of use. Generally, this structure is used for residential customers only. The "non-incremental" rate structure charges unit costs based on the number of units of water consumption equipment owned by the user.

Neither the size nor the ownership of the systems correlates well with type of rate structure. Prices charged for water are usually regulated by a state or local commission appointed to evaluate the need for rate hikes. Any rate increases necessary to implement these regulations will have to be approved by the appropriate commissions, but there is often a large lag time between rate increase requests and rate increase approvals.

Most water systems finance large capital investments by retaining profits and acquiring debt. Publicly-owned systems usually have access to municipal funds and are authorized to sell either general obligation bonds or revenue bonds. In some localities, however, water system finances have not been kept separate from general municipal funds. Private, investor-owned systems may issue stocks and bonds, but unlike public systems, their credit ratings are dependent on the profitability of their own operations.

There does not seem to be a correlation between present debt levels and long-term financial soundness in the water industry. Although almost one-fourth of the water systems are presently debt-free, approximately 85 percent of these debt-free systems serve communities of less than 5,000 people. However, many of these small investor-owned systems do not have positive net income, while larger water systems with high debt-to-book value ratios do have positive net incomes.

## 1.3 Costs to Meet the Proposed Interim Primary Drinking Water Regulations

### 1.3.1 Monitoring Costs

The implementation of the Proposed Interim Primary Drinking Water Regulations will cause all public water systems to initiate a routine monitoring program to assure that at least minimum standards of water quality are maintained. The cost associated with this monitoring activity is a function of both the size of the community and the source(s) of water.

Monitoring costs will be incurred by water systems as a result of the implementation of the Proposed Interim Primary Drinking Water Regulations in the following categories:

1. Routine monitoring costs for community water systems;

2. Costs incurred by community systems when maximum allowable limits are exceeded;

3. Costs incurred by community systems when the contaminant level is 75 percent or more of the maximum contaminant level;

4. Routine monitoring costs incurred by public water systems other than community systems;

5. Costs incurred by public non-community systems when maximum allowable limits are exceeded;

6. Costs incurred by public non-community systems when the contaminant level is 75 percent or more of the maximum contaminant level.

The Proposed Interim Primary Drinking Water Regulations call for the monitoring of four classes of contamination: inorganic, organic, microbiological, and turbidity. Turbidity monitoring is not considered here because these costs are considered to be negligible.

In order to develop a set of monitoring costs it was necessary to determine present laboratory analysis costs. These laboratory costs were obtained in the following three ways:

1. First-hand data from laboratories;
2. Data extrapolated from EPA manpower data on analysis requirements;
3. Actual analysis of cost data gathered from a survey of 207 plants which had failed at least one of the proposed mandatory regulations during a 1969 study.

The volume of coliform monitoring called for by the regulations makes the cost of coliform determination the most critical component in determining the overall costs of routine monitoring.

According to the methodology employed, the number of systems requiring routine monitoring is fixed by the number of ground- and surface-water supply systems in each discrete size range and the monitoring frequency prescribed by the regulations. Therefore, the only variable in the cost equation is the price per analysis, which is in turn dependent on the institutional monitoring arrangements made by each system. In this study, a range of costs is presented; the lower monitoring cost is represented by costs incurred by EPA in its laboratories, and the higher monitoring cost was calculated from costs which would be charged by moderately expensive commercial laboratories. Using a range of $5 to $10 per coliform analysis or plate count, $78 to $188 for a complete inorganic analysis, and $200 to $312 for a complete organic analysis, it is concluded that the routine monitoring costs for the 40,000 community systems would be between $22 million and $43 million per year. It is anticipated that many state laboratories will do the majority of the routine monitoring mandated by the regulations. If this is the case, then the actual national costs will fall on the low side of the calculated ranges.

To develop costs which would be incurred by systems to monitor their water supplies when maximum contaminant levels (MCL) are exceeded, information was needed on the number and type of analyses to be performed as well as on the cost per analysis. Again, EPA and commercial laboratory rates were used to establish cost ranges. The regulations state that when the coliform MCL is exceeded, daily samples shall be collected and examined from the same sampling point until at least two consecutive samples yield no positive results. Likewise, the regulations state that when either an inorganic or organic MCL is exceeded, a repeat analysis shall be done within 24 hours. Repeat analyses shall then be made at weekly intervals until the MCL has not been exceeded in samples taken on two successive weeks or until a monitoring schedule as a condition to a variance, exemption, or enforcement action shall become effective. Using these sampling criteria as guidance, it is possible to establish expected maximum and minimum sampling requirements. Because of the possibility of spread of contagious disease, it is extremely important that any coliform violations be corrected as soon as possible. For this reason it is expected that between 7 and 30 special coliform analyses will be performed, assuming violations will persist for one week to one month. For organic and inorganic violations it is expected that between 8 and 52 analyses will be performed, assuming that violations will continue for 8 to 52 weeks. Finally, the proposed regulations state that monthly analyses shall be made for each contaminant which is found at greater than 75 percent of the maximum contaminant level.

When the 1969 Community Water Supply Study (CWSS) was used to determine the number of systems which exceeded one or more MCL, a national monitoring cost of between $2.0 million and $11.1 million per year was calculated. It is important to recognize that the majority of these special monitoring costs will be incurred within the first two years after implementation of the regulations, due to the fact that those systems which are found to exceed an MCL in the first two years of monitoring will either install a treatment process or obtain a variance or exemption by the third year.

The cost components necessary to determine the national costs of routine monitoring for the 200,000 public non-community systems are the same as for the community systems. Calculations show that the nation's 200,000 non-community systems would require between $47 million and $92 million annually to perform routine monitoring. Special monitoring costs for the non-community systems would range between $1.6 million and $10.7 million if the same non-compliance criteria are used for both the community and non-community systems. The special monitoring costs were assumed to be spread over a 5-year period as systems are brought into compliance. Total monitoring costs for the first two years are summarized in Table 1-4.

The analysis shows that systems serving small populations vastly outnumber larger systems; therefore, small systems assume the greatest share of monitoring costs while serving an extremely small percentage of the population.

## TABLE 1-4

## TOTAL MONITORING COSTS MANDATED BY THE PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

| | FIRST YEAR ($ million) | SECOND YEAR ($ million) |
|---|---|---|
| Costs of Routine Monitoring for the 40,000 Community Systems | 22.2-42.8 | 22.2-42.8 |
| Monitoring Costs for Coliform Violations for 40,000 Community Systems | 0.3-3.2 | 0.3-3.2 |
| Monitoring Costs for Chemical Violations[a] for 40,000 Community Systems | 0.2-1.5 | 0.1-1.5 |
| Monitoring Costs When Between 75 and 100 Percent[a] of Maximum for 40,000 Community Systems | 0.6-1.4 | 0.6-1.3 |
| Routine Monitoring Costs for 200,000 Public Systems | 47.1-92.0 | 47.1-92.0 |
| Monitoring Costs for Coliform Violations[b] for 200,000 Community Systems | 0.3-2.1 | 0.3-2.1 |
| Monitoring Costs for Chemical Violations[b] for 200,000 Public Systems | 0.5-6.8 | 0.5-6.8 |
| Monitoring Costs When Between 75 and 100 Percent[b] of Maximum for 200,000 Public Systems | 0.8-1.9 | 0.8-1.9 |
| TOTAL | 72.0-151.7 | 71.9-151.6 |
| Present Coliform Monitoring Costs for 40,000 Community Systems | (-)7.3-14.4 | (-)7.3-14.4 |
| Present Coliform Monitoring Costs for 200,000 Public Systems | (-)1.2-2.4 | (-)1.2-2.4 |
| Additional Costs Mandated by Proposed Regulations | 63.5-134.9 | 63.4-134.8 |

[a] Assumes violations will be found during first two years of sampling.

[b] Assumes violations will be found during first five years of sampling.

Annual monitoring costs per capita are much higher for small systems. For systems serving less than 100 persons, the average per capita cost varies from about $5 to $10. Approximately 7,000 community systems fall in this category.

### 1.3.2 Treatment Costs

Once the monitoring program is initiated, many systems will find that they exceed one or more MCL and will then be faced with an additional cost in order to achieve the required MCL. There are several alternative routes which a system can pursue in order to comply with the regulations. One option is to install the treatment facilities capable of reducing the MCL to an acceptable level. Another option is to choose to use alternative less-contaminated sources of water. Finally, a combination of additional treatment and judicious management of water sources may achieve compliance with the regulations. The initial economic analysis assumed that the installation of treatment facilities would be the approach used to provide safe drinking water.

The costs incurred by a community in removing any contaminants are site-specific and are dependent on many interrelated factors such as treatment facilities presently available, age of system, and source of water. The following methodology was used to project national treatment costs mandated under the Interim Primary Drinking Water Regulations from the data base of 969 systems included in the 1969 CWSS, the April 1975 Chemical Analysis of Interstate Carrier Water Supply Systems, and the 1974-75 EPA Public Water Supply Inventory:

1. A cost estimate was made of the capital and O&M costs required to supply chlorination to 27.5 percent of the presently unchlorinated systems in the EPA inventory;

2. A cost estimate was made to determine the capital and annual O&M costs to clarify those water systems in the EPA inventory of 40,000 systems which have surface water supplies and do not clarify. The O&M and capital costs were determined by assuming that direct filtration would be the treatment chosen by those systems which require clarification;

3. Those systems shown to be having problems with a particular contaminant were assigned capital and O&M costs for correcting the violation. Lead treatment costs were determined using pH control as the treatment process; ion exchange was the treatment process chosen to treat for Cd, Cr, $NO_3$, Se, Hg, and Ba. Activated alumina absorption was chosen to remove excess fluoride and As, while activated carbon would remove CCE organics.

In each of the above cost projections both the maximum daily water production and the average daily production, as calculated from the Public Water Supply Inventory, were used to project national investment costs. Using the 1969 CWSS, projections were made of the number of systems which exceeded each MCL, except for coliform and turbidity.

On the basis of the above assumptions a national capital treatment cost range of approximately $1.1 billion to $1.8 billion was determined with a related annual O&M cost of $264 million (Table 1-5). The data show that the major expense would be incurred for clarification units to treat the nation's surface-water systems.

Cost estimates for non-community systems to comply with the regulations are also shown in Table 1-5. It was assumed that approximately 17 percent of all non-community systems will require chlorination and that all systems using surface sources will require clarification. Total investment costs are estimated to be about $24 million and annual operation and maintenance costs will be approximately $18 million.

## 1.4 Economic Impact of the Interim Primary Drinking Water Regulations

An estimate was made of the annual costs of capital, operation and maintenance, and monitoring necessary to comply with the regulations. Table 1-6 reiterates the costs for community systems.

The expenditures required to comply with the Proposed Interim Primary Regulations will have an impact on all water users except industrial water users who do not employ potable water in their production processes. The entire nation will feel the impact of monitoring costs to some extent, but the major costs of both capital and operation and maintenance

## TABLE 1-5

## NATIONAL COSTS OF TREATING CONTAMINANTS IN DRINKING WATER

| TREATMENT TECHNOLOGY | CONTAMINANT | CAPITAL COSTS ($ million) | ANNUAL O&M ($ million) |
|---|---|---|---|
| COMMUNITY SYSTEMS | | | |
| Clarification | Turbidity | 379.3-682.9 | 188.6 |
| Chlorination | Coliform | 170.0-27.4 | 7.2 |
| Ion Exchange | Ba, Cr, Cd $NO_3$, Hg, Se | 619.2-996.9 | 52.3 |
| Activated Alumina | Fluoride, As | 30.6-52.9 | 10.8 |
| pH Control | Pb | 2.7-4.2 | 0.1 |
| Activated Carbon | CCE | 22.5-35.8 | 4.6 |
| SUBTOTAL | | 1,071.3-1,800.1 | 263.6 |
| NON-COMMUNITY SYSTEMS | | | |
| Clarification | Turbidity | 10 | 1 |
| Chlorination | Coliform | 14 | 17 |
| SUBTOTAL | | 24 | 18 |
| TOTAL | | 1,095.5-1,824.3 | 281.6 |

## TABLE 1-6

### ESTIMATED NATIONAL COSTS OF IMPLEMENTING THE INTERIM PRIMARY DRINKING WATER REGULATIONS FOR COMMUNITY WATER SUPPLY SYSTEMS[a]
($ million)

| | |
|---|---|
| Total Capital Costs | 1,071 - 1,800 |
| Annual Capital Costs[b] | 150 - 252 |
| Annual O&M Costs | 264 - 264 |
| Annual Monitoring Costs | 22 - 42 |

[a] 1975 dollars.

[b] Assumes 7 percent annual interest on capital costs amortized over 15 years.

will be felt in those areas served by water systems not already meeting the MCL's. The impact of these costs will vary with the size of the water system involved. Table 1-7 summarizes these costs as they affect systems of different sizes.

It can be seen from Table 1-7 that the per capita cost in very small systems could be affected at a rate of up to seven times that in medium- and large-sized systems. In the smallest category, the average annual per capita cost of capital, O&M, and monitoring is approximately $9 to $56 ($36 to $224 for a family of four).

Records indicate that per capita consumption of water tends to decrease following significant increases in water rates. Among individual users the decrease would occur in those uses for which there is high elasticity of demand; e.g., lawn sprinkling. The demand of industrial and commercial users has been shown to be inelastic in the face of price increases. If demand declines sharply after initial rate hikes, a second increase may be necessary to cover the largely fixed costs of treatment. It is not certain how these costs will be financed -- either through higher taxes or higher water rates -- but it is certain that the Interim Drinking Water Regulations will have the greatest impact on those served by smaller water systems. Further study is under way to determine if financing will be a serious problem for large or small systems.

## TABLE 1-7

## DISTRIBUTION OF COSTS FOR THOSE SYSTEMS NEEDING TREATMENT BY SIZE OF SYSTEM FOR FOUR SIZE RANGES

| | SMALLEST SYSTEMS (25-99 PEOPLE SERVED) | SMALL SYSTEMS (100-9,999 PEOPLE SERVED) | MEDIUM SYSTEMS (10,000-99,999 PEOPLE SERVED) | LARGE SYSTEMS (OVER 100,000 PEOPLE SERVED) |
|---|---|---|---|---|
| Annual Capital Costs ($ million) | 3.8 - 6.4 | 60.8 - 102.1 | 53.6 - 90.0 | 31.8 - 53.4 |
| Annual O&M Costs ($ million) | 2.1 | 51.0 | 75.7 | 134.6 |
| Annual Monitoring Costs ($ million) | 0.5 - 1.0 | 0.9 - 1.8 | 1.8 - 3.8 | 1.9 - 4.2 |
| TOTAL ANNUAL COSTS ($ million) | 6.4 - 9.5 | 112.7 - 154.9 | 131.1 - 169.5 | 168.3 - 192.2 |
| Average Annual Cost per Capita ($) | 38 - 56 | 11 - 15 | 9 - 12 | 10 - 11 |
| Increase in Household Monthly Water Bill[a] ($) | 9.93 - 14.74 | 2.86 - 3.93 | 2.32 - 3.01 | 2.46 - 2.91 |

[a] Assumes 3.11 persons per household and all increases in costs passed on to the consumer.

Rather than install expensive treatment equipment, it is anticipated that many small systems would explore the following options:

1. Shift source of water from surface to ground;
2. Change groundwater sources;
3. Consolidate (merge) systems;
4. Purchase finished water;
5. Examine availability of grant programs such as that administered by the Farmers Home Administration;
6. Use exemption and variance procedures specified in the regulations.

The impact of these alternatives on the projected national costs is being explored. Specifically, viable alternative treatment technologies for small systems are being evaluated. In addition, a more detailed study of the economic and financial impact of these regulations is being made with particular emphasis given to small systems. The study will be based on detailed financial data and operational information gathered through a survey of a large sample of water companies. On the basis of these studies, an evaluation of the above alternatives will be made at a later date.

At the present time EPA believes that the economic impact of the construction requirements will be spread over at least a 4-year period from the date of the promulgation of the regulations because the regulations will not result in immediate compliance. The effective date of the regulations will be 18 months after promulgation. Noncompliance may not be discovered until initial sampling has been completed. Once the regulations take effect, the deadlines for initial sampling of community water supplies will range from one day for turbidity to two years for inorganic samples of groundwater systems. Therefore, in some cases, more than three years could elapse after promulgation before inorganic violations would be detected and corrective actions initiated. In addition, the use of the exemption or variance provisions of the regulations could further prolong compliance for public water systems unable to comply for economic or technical reasons.

It is estimated that the investor-owned water systems would pay approximately one-fourth of the total treatment costs, while the publicly-owned companies would pay the remainder. However, since many of the investor-owned systems serve very small populations, the capital demands on these systems could be substantial.

In 1974, the water supply industry spent approximately $1.5 billion for capital improvements. The average total annual capital costs mandated by the interim primary regulations are estimated to be between 13 and 24 percent of this figure. It is anticipated that the industry as a whole would be able to raise the additional necessary capital. Small firms will, however, encounter difficulty in financing new treatment facilities, particularly when ion exchange, a relatively expensive treatment process, is required. The implementation of the regulations will force many communities to allocate economic resources, which might be needed to provide other services to the community, for the treatment of their drinking water.

The macroeconomic effects of the Interim Primary Drinking Water Regulations are expected to be minimal. On the average, the regulations will cause an increase in water rates of 9.5 percent spread over several years. If this increase occurred in one year, the resulting increase in the Consumer Price Index (CPI) would be less than 0.001 percent. Since the costs of these regulations will be incurred over several years, the average annual increase in the CPI will be even less. The Chase Econometric Model predicts an estimated average annual increase in the CPI of less than 0.1 percent due to all pollution abatement programs.[1]

## 1.5 Constraints to Implementation of the Interim Primary Drinking Water Regulations

Potential non-economic constraints to the implementation of the regulations were examined in several broad areas including: chemicals and supplies, manpower, laboratories, and engineering and construction services.

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[1] Chase Econometric Associates, Inc., "The Macroeconomic Impacts of Federal Pollution Control Programs," prepared for the Council of Environmental Quality and the Environmental Protection Agency, January 1975.

The implementation of the Proposed National Interim Primary Drinking Water Regulations within a reasonable time frame would greatly depend on the availability of key chemicals and supplies needed in the treatment of drinking water. In particular, the interim regulations will increase demand for coagulants and disinfecting agents. It is anticipated that this increased demand could cause some temporary dislocations in chemical markets, but that increased demand will result in an expansion of supplies in the long run.

It is projected that the 1980 demand for ferric chloride may increase by 15 to 20 percent over the present production levels, while alum demand will be approximately 15 percent greater than current production. There is a general consensus that organic polyelectrolytes will become the dominant flocculating agents in the future. However, there are no reliable estimates of which polyelectrolyte(s) will be dominant and when the shift in chemical usage will occur.

Approximately 180,000 people are currently employed in the water supply industry. With the implementation of the Interim Primary Drinking Water Regulations approximately 26,000 additional personnel would be needed nationwide. These personnel would be required to perform such tasks as monitoring and enforcing the regulations, operating the required treatment facilities, and performing laboratory analysis of water samples, program assistance and program administration. It is anticipated that water systems may have difficulty hiring qualified personnel.

The third potential constraint is in the availability of adequate laboratories to perform the required chemical and biological analyses. Coliform monitoring is now being performed at state, local and private laboratories. In meeting the coliform monitoring requirements, water suppliers should not have difficulty finding laboratory facilities. At the present time there is little routine monitoring to measure the heavy metals and organic compounds of concern in the regulations. However, there are adequate numbers of public and private laboratories capable of performing these analyses, although state certification of laboratories, as required by the regulations, could constrain available laboratory facilities.

The final area where constraints could occur is in the design and construction of the required treatment facilities. Although the annual cost of required new construction represents less than 0.4 percent of the present total annual new construction in the United States, design and construction of new water treatment plants is a highly specialized activity. Some communities, especially those in rural areas, may have difficulty obtaining these services due to their expense or unavailability.

## 1.6 Limits of the Analysis

In developing the cost estimates used in this study, it was necessary to use several simplifying assumptions. This section explores these assumptions and their overall impact.

The first assumption is that there are 40,000 community water supply systems in the nation and that they are represented accurately by the current EPA inventory of community water supply systems. There is some evidence, however, that when the inventory is completed there will be a total of 50,000 community systems rather than the estimated 40,000. This increase in systems would cause a concomitant increase in monitoring costs of about 12 percent and a similar increase in treatment costs.

All costs for public non-community systems were based on the assumption that there are 200,000 of these systems nationwide. At the present time there is no accurate inventory of these systems; thus, this number is merely an estimate. It is anticipated that the EPA will be performing an inventory of these systems in the next few years so that these estimates can be updated.

Present average daily water production was determined for nine discrete population groups. This data base was developed from the ongoing EPA inventory of community supplies. Although these average production rates were used to develop treatment costs, there is no way to determine the number of systems which would design their treatment capacity to reflect future growth and reserve capacity rather than present needs.

Another major consideration in developing treatment costs is that many systems may use alternative water management practices rather than install more costly treatment processes. For example, groundwater systems might blend water from a "clean" well with that from a "dirty" well so that the resultant water would not exceed the MCL. Similarly, no estimate is possible to determine the possible benefits which might result from cascading treatment processes. For example, clarification units might remove enough heavy metals so that the MCL for metals might not be exceeded. These treatment alternatives would vary from site to site so that it is impossible to quantify the benefits which would be derived.

## 1.7 Energy Use

It is estimated that approximately 21,000 billion Btu's per year will be required to operate plants and produce chemicals for the various treatment systems necessary for the 40,000 community systems to meet the regulations. This is about 0.028 percent of the 1973 national energy consumption, based on data from the 1974 Statistical Abstract. The actual increase in energy use will depend on a number of factors, including whether pollution in surface-water sources is successfully controlled. There will be no direct energy savings from the recommended action.

# CHAPTER TWO

# INTRODUCTION

## 2.0 Safe Drinking Water Act of 1974

The objective of the Safe Drinking Water Act is to provide for the safety of drinking water supplies throughout the United States through the establishment and enforcement of national drinking water regulations. The Congress has authorized the Environmental Protection Agency to promulgate national drinking water regulations. The individual states will have the primary responsibility for enforcing the regulations, providing general supervisory aid to the public water systems, and inspecting all sources of drinking water.

The major provisions of the Safe Drinking Water Act can be summarized as follows:

1. Establishment of primary regulations for the protection of the public health;
2. Establishment of secondary regulations relating to odor and appearance of drinking water;
3. Protective measures for underground drinking water sources;
4. Research and studies regarding health, economic, and technological problems associated with drinking water supplies are to be undertaken. Studies of viruses in drinking water and contamination by cancer-causing chemicals are specifically required;
5. A survey of rural water supplies to be performed;
6. Aid to the states in improving drinking water programs through technical assistance, training of personnel, and grant support. A loan guarantee to be provided to assist small water systems in meeting regulations if other means of financing cannot be reasonably found;

7. Citizen suits to be filed against any party believed to be in violation of the Act;

8. Record-keeping, inspections, issuance of regulations, and judicial review;

9. A 15-member National Drinking Water Advisory Council to advise the Administrator of EPA on scientific and other responsibilities under the Act;

10. A requirement of the Secretary of Health, Education, and Welfare to insure that the standards for bottled drinking water conform to the primary regulations established under the Act or to publish reasons for not doing so;

11. Authorization of appropriations totalling $156 million for fiscal years 1975, 1976, and 1977.

## 2.1 Interim Primary Drinking Water Regulations

The Congress mandated that the Environmental Protection Agency establish the Interim Primary Drinking Water Regulations within six months after passage of the Act. The major provisions of the Proposed Primary Regulations can be summarized as follows:

1. Establish definitions of the two types of "public" water supply systems;

2. Set range of applicability and coverage of standards;

3. Establish monitoring frequencies;

4. Establish analyses methodology criteria;

5. Establish maximum contaminant levels for certain inorganic, organic, and biological substances;

6. Establish a laboratory certification criterion;

7. Establish procedure for notifying consumers of variances, exemptions, and non-compliance with standards;

8. Establish reporting requirements for systems failing any standard;

9. Establish criteria for locating future water supplies;

10. Set the effective date to be 18 months after promulgation of the standards.

A copy of the Proposed Interim Primary Drinking Water Regulations as published in the March 14, 1975 Federal Register can be found in Appendix A.

## 2.2 Study Objective

The objective of this study is to provide an analysis of the effects of implementing the Proposed Interim Drinking Water Regulations as published in the March 14, 1975 Federal Register. The remainder of this study is composed of seven chapters. Chapter Three briefly describes the history and characteristics of the water supply industry as well as relevant information on the data bases used in this study.

Chapter Four develops the total national costs for monitoring the 40,000 community systems and 200,000 public non-community systems. This chapter also develops the costs of treatment for those systems which would exceed one or more maximum contaminant levels. Finally, this chapter explores the sensitivity of these costs and analyzes the key variables.

Chapter Five explores those non-economic variables which might act as constraints to implementation of the Proposed Interim Primary Drinking Water Regulations. In particular, the study examines the availability of manpower, key materials, laboratories, and engineering resources.

Chapter Six predicts the manner in which the monitoring and treatment costs would be spent over the next 10 years and examines the feasibility of financing these costs. The chapter also examines the financial structure of the industry and the availability of funding for the incurred costs.

Chapter Seven examines the impact of the monitoring and treatment costs both separately and cumulatively. This chapter shows the distribution of costs among the commercial, industrial and private sectors. The impact on both the private (investor-owned) sector and the public sector is also explored, as are the cost effects on different size systems (by population served).

Chapter Eight makes explicit the major assumptions underlying this study, explores them in some detail, and discusses the limits of their validity, with the objective of bringing the overall analysis into perspective.

Chapter Nine analyzes several alternative policy decisions for implementing the Primary Drinking Water Regulations. The impact of these alternatives on costs, manpower, and chemical constraints is examined in this chapter.

# CHAPTER THREE

## THE WATER SUPPLY INDUSTRY

### 3.0 General Description

The water supply industry, classified by the Department of Commerce as SIC group 4941, maintains facilities to supply water primarily for domestic, commercial, and industrial use. This classification excludes facilities which provide water for irrigation. The present study deals with that portion of SIC group 4941 providing water for general community usage.

The water supply industry produces more tons of finished goods (approximately 85 million tons daily) than any other U.S. industry. It is estimated that in 1970 public water supplies delivered over 27 billion gallons of water per day (bgd), of which about 63 percent was used for residential purposes.[1] The needs of public water utilities are expected to increase to about 33.6 bgd by 1980. As shown in Table 3-1 this amount would be roughly 7.6 percent of all water used in the U.S. at that date. At the present time there are an estimated 40,000 community water supply facilities in the United States serving approximately 177 million people daily.

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[1] C.R. Murray and E.B. Reeves, Estimated Water Use in the U.S. - 1970, U.S. Geological Survey, Department of the Interior, 1972.

TABLE 3-1

U.S. TOTAL WATER USE 1970-1980 (mgd)[a]

| USE CATEGORY | 1970 | % of TOTAL | 1980 | % of TOTAL |
|---|---|---|---|---|
| IRRIGATION | 119,180 | 36.4 | 135,850 | 30.7 |
| RURAL DOMESTIC | 4,340 | 1.3 | 4,850 | 1.1 |
| INDUSTRIAL & MISCELLANEOUS | 55,950 | 17.1 | 75,030 | 17.0 |
| STEAM ELECTRIC | 120,800 | 36.9 | 193,030 | 43.6 |
| WATER UTILITIES | 27,030 | 8.3 | 33,600 | 7.6 |
| TOTAL | 327,300 | 100.0 | 442,360 | 100.0 |

[a] There are 0.00378 $m^3$ per gallon.

Source: U.S. Water Resources Council, "The Nation's Water and Related Land Resources," The Nation's Water Resources (Washington, D.C.: U.S. Gov't. Printing Office, 1968), p. I-18.

## 3.1 History

Prior to the start of the 19th century, most water supply and treatment activity in all parts of the world was limited to individual applications of rudimentary purification and clarification processes. Filtered water was first supplied to an entire town through pipelines in Glasgow, Scotland in 1807.[1]

In the United States the public water supply industry is one of the oldest of industries, dating back to a wooden conduit distribution system built in Boston, Massachusetts during the mid-1600's.[2] The first water distribution system to serve an entire town in the United States was constructed in Pennsylvania almost a century later in 1746.[1] However, water treatment did not receive wide scale attention until after the Civil War.

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[1] J.W. Clark et al., Water Supply and Pollution Control, International Textbook Co. (Scranton, Pa.: Haldon Craftsmen, Inc., 1971).

[2] American Water Works Association - Staff Report, "The Water Utility Industry in the United States," submitted to the U.S. Congress, Joint Economic Committee, April 1966.

Public water service was not immediately accepted; there were only about 16 public water systems in service in the year 1800 (see Table 3-2). Early Americans preferred to take their water from nearby wells. During the first half of the 19th century the principal means of supplying water to cities and towns shifted from pumping small volumes manually from wells in the community to bringing in abundant amounts of piped water from larger external sources.[2]

TABLE 3-2

19th CENTURY WATER UTILITY GROWTH

| YEAR | NUMBER OF UTILITIES |
|---|---|
| 1800 | 16 |
| 1825 | 32 |
| 1850 | 83 |
| 1875 | 422 |
| 1890 | 598 |
| 1900 | 1,013 |

Source: American Water Works Association - Staff Report, 1966.

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[1] American Water Works Association - Staff Report, "The Water Utility Industry," April, 1966.

[2] G.M. Fair et al., Elements of Water Supply and Wastewater Disposal (New York: John Wiley and Sons, 1971).

The first municipal water purification plant built in the United States was constructed in Virginia in 1832 and was the forerunner of several hundred plants built during the 1800's. The evolution of organized public systems in the 19th century was closely related to the growth of cities and towns around industrial developments. Water system management by private water companies became prevalent and service was continually improved. By the end of the century publicly-operated water utilities were more numerous and delivered an increasing volume of water to the growing cities of America. In 1900 about 22 million people were being served by public water systems.[1]

The development of water utilities during the past 75 years has paralleled that of other essential service industries. Water usage in the public water utility industry for the period 1900-1980 is shown in Figure 3-1.

## 3.2 Organization

Although the water supply industry provides a universally essential product, it is an atypical industry in many respects. As it has expanded to keep pace first with a geographically expanding agrarian society and then with a growing, more densely populated urban industrial society, a variety of water utility types has evolved. At present the industry is composed of:

1. Full service companies that develop, store, treat and distribute water;
2. Companies that develop water sources and maintain storage and treatment facilities, but do not own and/or manage distribution works;
3. Companies that are solely involved in the distribution of water supplies.

In many cases public water utilities operate as both full and partial service companies. In many regions large metropolitan area utilities manage all aspects of water supply to major population centers, and also sell water to distribution companies servicing smaller, outlying cities and towns.

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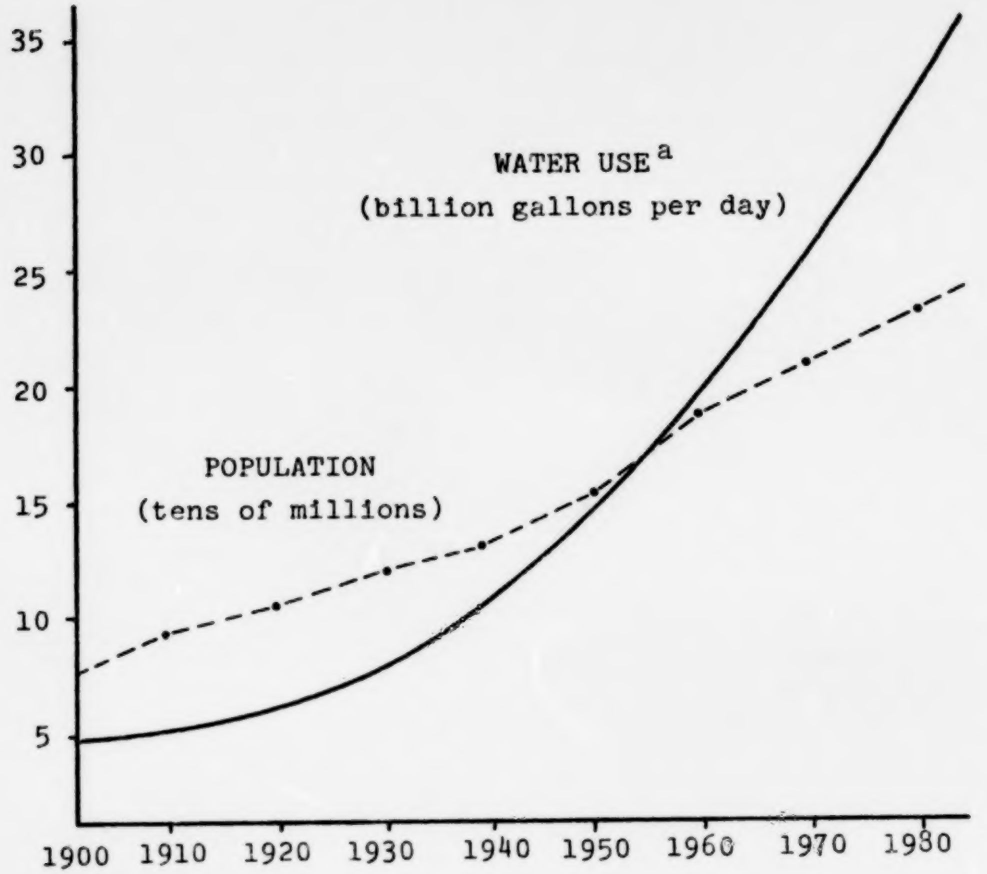
[1] American Water Works Association - Staff Report, "The Water Utility Industry," April 1966.



[a] There are 0.00378 $m^3$ per gallon.

Figure 3-1. This graph illustrates public water utility water needs for the years 1900 to 1980. (CRC Handbook of Environmental Control, vol. III: Water Supply & Treatment, 1973, p. 131.) (Population data from: Social Indicators 1973, Office of Management and Budget, 1973, p. 233.)

Larger metropolitan area water utilities are able to take advantage of economies of scale in meeting the costs of facility maintenance, developing new sources to meet growing demands, and constructing additional treatment facilities. Smaller public water systems are limited in their ability to adjust to rising capital needs, so that the consolidation of smaller utilities into larger water districts or their outright absorption into larger utilities may occur. This is not attributable to market competition between companies of varying size serving contiguous communities, but is rather the result of non-competing water utilities adapting to changing economies of operation by altering management structures. For public water systems, the responsibility to provide wholesome water overrides any regional or local competitiveness which might exist.

## 3.3 Customers

Water supply systems provide water service for residential, commercial, industrial and general municipal purposes. An approximate allocation of the water supplied by water utilities to the various categories of users is shown in Table 3-3.

TABLE 3-3

COMMUNITY WATER SUPPLY USE BY CATEGORY

| TYPE OF USE | PERCENT OF TOTAL |
|---|---|
| Residential | 63 |
| Commercial | 11 |
| Industrial | 21 |
| Municipal | 5 |
| TOTAL | 100 |

Source: U.S. Geological Survey estimates, 1972.

Residential water usage includes drinking, cooking, bathing, flushing, cooling, washing, laundering, and lawn sprinkling. Water is supplied to commercial businesses such as restaurants, motels, hotels, laundries, florists, etc., for the same general purposes. Water supplied by public utilities is used in all types of industry for both sanitary and process-related service, and especially in smaller factories or industries unable to develop and maintain their own water supplies. One of the prime considerations in a community's industrial development is its ability to supply adequate amounts of water for process and other needs of a variety of industries.

The category of general municipal service includes the public use of water for sprinkling, swimming pools, fountains, public buildings and fire-fighting. The provision of fire protection service represents a major portion of the investment in water works facilities, especially for smaller utilities. The general policy of the American Water Works Association, an industry trade organization, is that supply water must (1) be free of undesirable taste, odor, color, turbidity and corrosiveness; (2) be supplied in quantities sufficient to ensure sanitary and fire protection service; (3) be available on an uninterrupted basis without system pressure fluctuations; and (4) be safe for public consumption.

## 3.4 Community Water Systems

Community water systems and public non-community water systems are treated separately due to the great disparity between the amount of data available for the two types.

The Proposed Interim Primary Drinking Water Regulations define the term "public water system" as a system for the provision to the public of piped water for human consumption, if such a system has at least 15 service connections or regularly serves an average of at least 25 individuals daily, at least three months out of the year. The term "community water system" is defined as a public water system which serves a population of which 70 percent or greater are residents. Table 3-4 synopsizes the information available on community water supply systems.

The first issue to be examined concerning community water supply systems is the number of systems which fall under the Environmental Protection Agency's definition. Two studies which have broadly addressed this issue are the ongoing Environmental Protection Agency Community Water Supply Inventory and the 1974 National Sanitation Foundation (NSF) Report entitled Staffing and Budgetary Guidelines for State Drinking Water Supply Agencies.

TABLE 3-4

AVAILABLE INFORMATION ON COMMUNITY WATER SUPPLY SYSTEMS

| | SOURCE OF INFORMATION | NUMBER OF SYSTEMS IN STUDY | QUANTITATIVE DATA | QUALITATIVE DATA | FINANCIAL DATA | TREATMENT DATA |
|---|---|---|---|---|---|---|
| 1. | EPA Community Water Supply Inventory | 39,277[a] | X | | | X |
| 2. | CWSS of 1969 | 969 | X | X | X | X |
| 3. | EPA Interstate Carrier Water Supplies (1975) | 730 | X | X | | X |
| 4. | 10 EPA-State Water Quality Evaluations | 397 | X | X | | X |
| 5. | 1970 AWWA Statistical Report | 768 | X | | X | X |
| 6. | National Santitation Foundation 1974 Report | 49,166 | X | | | |

[a] As of July 15, 1975.

The results of these two studies (and a 1975 ERCO study) are shown in Table 3-5. The data for the NSF report were obtained from a survey done in January 1974; 42 states provided data at that time. The data on Table 3-5 show that at present there is no clear breakdown of the number of community water systems in the nation. The differences between the NSF, EPA and ERCO numbers can be explained by differences in the definitions of a community system employed. The National Sanitation Foundation report defines a community water supply system as a public system that provides water to 10 or more premises not owned or controlled by the supplier of water or to 40 or more resident individuals. The ERCO survey of all 50 states (Appendix B) found that many states which supplied information to the EPA inventory used definitions of a community supply which were markedly different than that given in the Proposed Interim Primary Regulations. For the purpose of this report, ERCO uses the EPA estimate of 40,000 community water supply systems as a valid approximation, although it is quite possible that the EPA will raise this number when all states adopt the same definition of a community system.

Given the estimated 40,000 community systems in the United States, it is important to characterize the systems by different variables, since the interim regulations mandate different monitoring practices depending on the water source and size of population served. Table 3-6 separates the EPA community inventory of water systems, the 1969 Community Water Supply Systems study (CWSS), the EPA Interstate Carrier Water Supply survey, the 1970 American Water Works Statistical Report (AWWA), and the 10 EPA-State water quality evaluations by the percentage of systems in each population class. Table 3-7 breaks the results of these same five studies into categories based on the percentage of systems which draw water from either surface, ground, mixed, or purchased sources. A final method of distinguishing water supplies is by current degree of treatment. Table 3-8 shows the percentage of systems which utilize one or more of the following treatment processes: aeration, prechlorination, coagulation, sedimentation, filtration, softening, taste and odor control, iron removal, ammoniation, fluoride adjustment, and disinfection.

For the purpose of this study the ongoing EPA Inventory of Community Water Supplies is considered to be representative of the nation as a whole with regard to population served, treatment facilities, and source of water.

TABLE 3-5

## NUMBERS OF COMMUNITY WATER SUPPLY SYSTEMS BY STATE

| | 1974 NSF[a] STUDY | ONGOING EPA[b] INVENTORY | 1975 ERCO SURVEY |
|---|---|---|---|
| ALABAMA | 305 | 489 | |
| ALASKA | 69 | 231 | |
| ARIZONA | 1,000 | 442 | 1,912 |
| ARKANSAS | 500 | 461 | |
| CALIFORNIA | 3,200 | 3,035 | 4,100 |
| COLORADO | 700 | 561 | |
| CONNECTICUT | 395 | 449 | |
| DELAWARE | 139 | 143 | |
| DISTRICT OF COLUMBIA | | 8 | |
| FLORIDA | 1,800 | 690 | |
| GEORGIA | 3,184 | 2,099 | |
| HAWAII | 50 | 82 | 125 |
| IDAHO | 274 | 345 | 945 |
| ILLINOIS | 1,571 | 1,063 | 1,620 |
| INDIANA | 550 | 959 | 463 |
| IOWA | 1,465 | 929 | 822 |
| KANSAS | 669 | 558 | 830 |
| KENTUCKY | 500 | 462 | |
| LOUISIANA | 500 | 554 | |
| MAINE | 200 | 307 | 170 |
| MARYLAND | 316 | 314 | 810 |
| MASSACHUSETTS | 380 | 419 | |
| MICHIGAN | 1,974 | 1,606 | 2,216 |
| MINNESOTA | 680 | 527 | |
| MISSISSIPPI | 2,100 | 571 | |
| MISSOURI | 913 | 1,243 | |
| MONTANA | 221 | 168 | |
| NEBRASKA | 500 | 456 | 460 |
| NEVADA | 93 | 201 | |
| NEW HAMPSHIRE | 325 | 335 | |
| NEW JERSEY | 650 | 534 | 496 |
| NEW MEXICO | 353 | 116 | 370 |
| NEW YORK | 2,000 | 1,150 | |
| NORTH CAROLINA | 2,387 | 2,389 | 2,707 |
| NORTH DAKOTA | 245 | 99 | 257 |
| OHIO | 1,765 | 3,379 | 1,652 |
| OKLAHOMA | 600 | 789 | 860 |
| OREGON | 590 | 479 | |
| PENNSYLVANIA | 5,000 | 2,439 | 4,375 |
| RHODE ISLAND | 50 | 110 | 52 |
| SOUTH CAROLINA | 920 | 900 | |
| SOUTH DAKOTA | 250 | 180 | |
| TENNESSEE | 520 | 454 | |
| TEXAS | 3,700 | 1,862 | 6,900 |
| UTAH | 408 | 268 | 665 |
| VERMONT | 350 | 301 | 371 |
| VIRGINIA | 1,400 | 1,088 | |
| WASHINGTON | 1,500 | 1,622 | 1,600 |
| WEST VIRGINIA | 1,000 | 633 | |
| WISCONSIN | 600 | 722 | |
| WYOMING | 107 | 56 | 418 |
| TOTAL | 49,166 | 39,277 | |

[a] National Sanitation Foundation Report, Staffing and Budgetary Guidelines for State Drinking Water Agencies, 1974.

[b] This data is based on inventory as of July 15, 1975 and is currently being updated.

No entry indicates lack of response.

## TABLE 3-6

## BREAKDOWN OF FIVE COMMUNITY WATER SURVEYS BY PERCENTAGE[a] OF SYSTEMS IN EACH OF NINE POPULATION CATEGORIES

| POPULATION RANGE | EPA COMMUNITY INVENTORY | 1969 CWSS | 1975 EPA INTERSTATE CARRIER | 10 EPA-STATE STUDIES | 1970 AWWA |
|---|---|---|---|---|---|
| 25-99 | 17.5 | 12.2 | 0.8 | 3.9 | 0.1 |
| 100-499 | 37.8 | 31.1 | 2.4 | 23.3 | 0 |
| 500-999 | 13.5 | 11.1 | 1.7 | 12.1 | 0 |
| 1,000-2,499 | 12.9 | 14.2 | 3.8 | 14.8 | 0 |
| 2,500-4,999 | 6.5 | 8.8 | 5.2 | 12.6 | 0 |
| 5,000-9,999 | 4.6 | 8.6 | 8.4 | 7.6 | 0 |
| 10,000-99,999 | 6.5 | 11.5 | 47.7 | 23.3 | 77.8 |
| 100,000-999,999 | 0.6 | 2.4 | 27.8 | 7.2 | 20.2 |
| >1,000,000 | <0.1 | 0.1 | 2.2 | 0 | 1.9 |
| TOTAL | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

[a] Based on percentages of systems reporting a population of 25 or greater.

TABLE 3-7

PERCENTAGE OF COMMUNITY WATER SYSTEMS WHICH UTILIZE EACH OF FOUR SOURCES OF WATER FOR FIVE STUDIES

| SOURCE OF WATER | EPA COMMUNITY INVENTORY | 1969 CWSS | EPA INTERSTATE CARRIER | 10 EPA-STATE STUDIES | 1970 AWWA |
|---|---|---|---|---|---|
| Ground[a] | 78.2 | 75.2 | 29.9 | 60.5 | 40.4 |
| Surface[b] | 11.5 | 21.6 | 48.3 | 32.6 | 34.7 |
| Mixed[c] | 3.4 | 3.2 | 15.6 | 4.3 | 14.9 |
| Purchased[d] | 6.9 |  | 6.2 | 2.5 | 10.0 |
| TOTAL | 100.0 | 100.0 | 100.0 | 99.9 | 100.0 |

[a] Includes ground and (ground and purchased).

[b] Includes surface and (surface and purchased).

[c] Includes ground and surface and (ground and surface and purchased).

[d] Includes purchased only.

## TABLE 3-8

## PERCENTAGE OF TREATMENT PROCESSES[a]

| TREATMENT | EPA COMMUNITY INVENTORY | 1969 CWSS | 10 EPA-STATE STUDIES | 1970 AWWA |
|---|---|---|---|---|
| Aeration | 6.6 | 6.2 | 4.8 | - |
| Prechlorination | 7.8 | 10.7 | 3.8 | - |
| Coagulation | 11.3 | 11.4[b] | 12.6 | 46.3 |
| Sedimentation | 8.9 | 10.0 | 13.1 | - |
| Filtration | 12.8 | 14.2 | 13.7 | 53.0 |
| Softening | 4.9 | 11.4[b] | 4.1 | 18.1 |
| Taste and Odor Control | 3.4 | 3.4 | 2.5 | 36.2 |
| Iron Removal | 5.7 | - | 0.8 | 24.5 |
| Ammoniation | 0.9 | 0.2 | 0.2 | - |
| Fluoride Adjustment | 8.5 | 4.9 | 7.7 | 42.9 |
| Disinfection | 49.7 | 40.3 | 24.2 | 77.2 |

[a] Percentages are not additive since some systems have multiple treatments and many systems have no treatment.

[b] 11.4 is total for Coagulation + Softening.

## 3.5 Production

The regional variation in production per capita is shown in Table 3-9. This table illustrates the tremendous variation in per capita daily production reported in each of the 10 EPA regions. The number of plants and total daily production for six size categories are shown in Table 3-10. This table shows that while 68 percent of the systems are in the two smallest categories, they contribute only 2.1 percent of total water production. In contrast, the largest 1.2 percent of the systems provide almost 62 percent of the total national community water production.

TABLE 3-9

AVERAGE DAILY U.S. WATER PRODUCTION PER CAPITA BY EPA REGION

| REGION | AVERAGE PRODUCTION PER CAPITA (gal/day)[a] |
|---|---|
| I | 145 |
| II | 159 |
| III | 155 |
| IV | 155 |
| V | 176 |
| VI | 180 |
| VII | 144 |
| VIII | 219 |
| IX | 168 |
| X | 202 |

[a] There are 0.00378 $m^3$ per gallon.

## 3.6 Ownership

Table 3-11 lists the 1970 production figures for publicly-owned water supply systems by size and treatment category. The distribution of production by privately-owned systems, listed by treatment and size is displayed in Table 3-12.

Of the 40,000 community systems presently supplying water, the data indicate that 58 percent are publicly-owned and that 42 percent are privately (investor-) owned.

## TABLE 3-10

## NUMBER OF SYSTEMS AND TOTAL DAILY PRODUCTION FOR SEVEN PRODUCTION CATEGORIES

| PRODUCTION CATEGORY (Millions of Gallons Per Day)[a] | COMMUNITY SYSTEMS |  | PRODUCTION |  |
|---|---|---|---|---|
|  | NUMBER | % OF TOTAL | MILLIONS OF GALLONS PER DAY | % OF TOTAL |
| <.01 | 8,875 | 22.2 | 43 | 0.1 |
| .01-0.1 | 18,331 | 45.8 | 624 | 2.0 |
| 0.1-1.0 | 9,300 | 23.2 | 2,957 | 9.1 |
| 1.0-10.0 | 3,036 | 7.6 | 8,608 | 27.0 |
| 10.0-30.0 | 325 | 0.8 | 5,477 | 17.2 |
| 30.0-50.0 | 69 | 0.2 | 2,232 | 7.0 |
| >50.0 | 64 | 0.2 | 11,958 | 37.6 |
| TOTAL | 40,000 | 100.0 | 31,899 | 100.0 |

[a] There are 0.00378 $m^3$ per gallon.

## TABLE 3-11

## PUBLICLY-OWNED WATER SYSTEM PRODUCTION (mgd)[a] BY SIZE AND TREATMENT TYPE

| SIZE | TREATED WATER | NON-TREATED WATER | TOTAL |
|---|---|---|---|
| Very Small<br><0.1 mgd | 224 (5,946)[b] | 192 (6,420) | 416 (12,366) |
| Small<br>0.1-10 mgd | 7,321 (7,256) | 2,740 (3,252) | 10,061 (10,508) |
| Medium<br>10-30 mgd | 3,564 (211) | 1,007 (61) | 4,571 (272) |
| Large<br>>30 mgd | 12,133 (97) | 964 (17) | 13,097 (114) |
| TOTAL | 23,242 (13,510) | 4,902 (9,750) | 28,145 (23,260) |

[a] There are 0.00378 $m^3$ per gallon.

[b] Numbers in parentheses indicate number of plants in each category.

TABLE 3-12

## PRIVATELY-OWNED WATER SYSTEM PRODUCTION (mgd)[a] BY SIZE AND TREATMENT TYPE

| SIZE | TREATED WATER | NON-TREATED WATER | TOTAL |
|---|---|---|---|
| Very Small<br><0.1 mgd | 81 (3,301)[b] | 171 (11,585) | 252 (14,886) |
| Small<br>0.1-10 mgd | 1,028 (1,201) | 418 (627) | 1,446 (1,828) |
| Medium<br>10-30 mgd | 769 (36) | 137 (19) | 906 (55) |
| Large<br>>30 mgd | 1,017 (45) | 77 (2) | 1,094 (47) |
| TOTAL | 2,895 (4,583) | 803 (12,233) | 3,698 (16,816) |

[a] There are 0.00378 $m^3$ per gallon.

[b] Numbers in parentheses indicate number of plants in each category.

As can be deduced from Tables 3-11 and 3-12, 88 percent of the production is from publicly-owned systems, with private (investor-owned) systems contributing about 12 percent. Investor-owned utilities are self-supporting enterprises, while public supplies may be either self-supporting or tax-supported. Because of greater risk and the lack of tax-exempt status, the investor-owned companies have a higher cost of capital. Thus, they generally charge higher rates per unit than municipal systems (Figure 3-2).

## 3.7 Public Non-Community Water Supply Systems

In general there is very little information on the estimated 200,000 public non-community water systems. This section summarizes the information available on those supply systems which serve drinking water to the transient public. These systems are found at service stations, motels, restaurants, rest areas, campgrounds, state parks, beaches, national parks, national forests, dams, reservoirs, and other locations daily frequented by the travelling public. (Appendix C gives an estimated breakdown of these 200,000 systems by use category and population served.)

Table 3-13, Column 1, shows estimates of the number of public non-community water supply systems in each state as presented in a National Sanitation Foundation study.[1] The information was obtained from the following sources:

1. An NSF survey by questionnaire to each state in January 1974. Forty-two states responded. Some of these states gave no estimate of the number of "Other Systems."

2. An EPA Regional Office survey by direct contact with the states in each region in 1970.

3. A Conference of State Sanitary Engineers survey conducted with the assistance of EPA in January 1973. Twenty-six states responded.

4. A 1974 NSF estimate of "Other Systems" in the seven states which did not respond to

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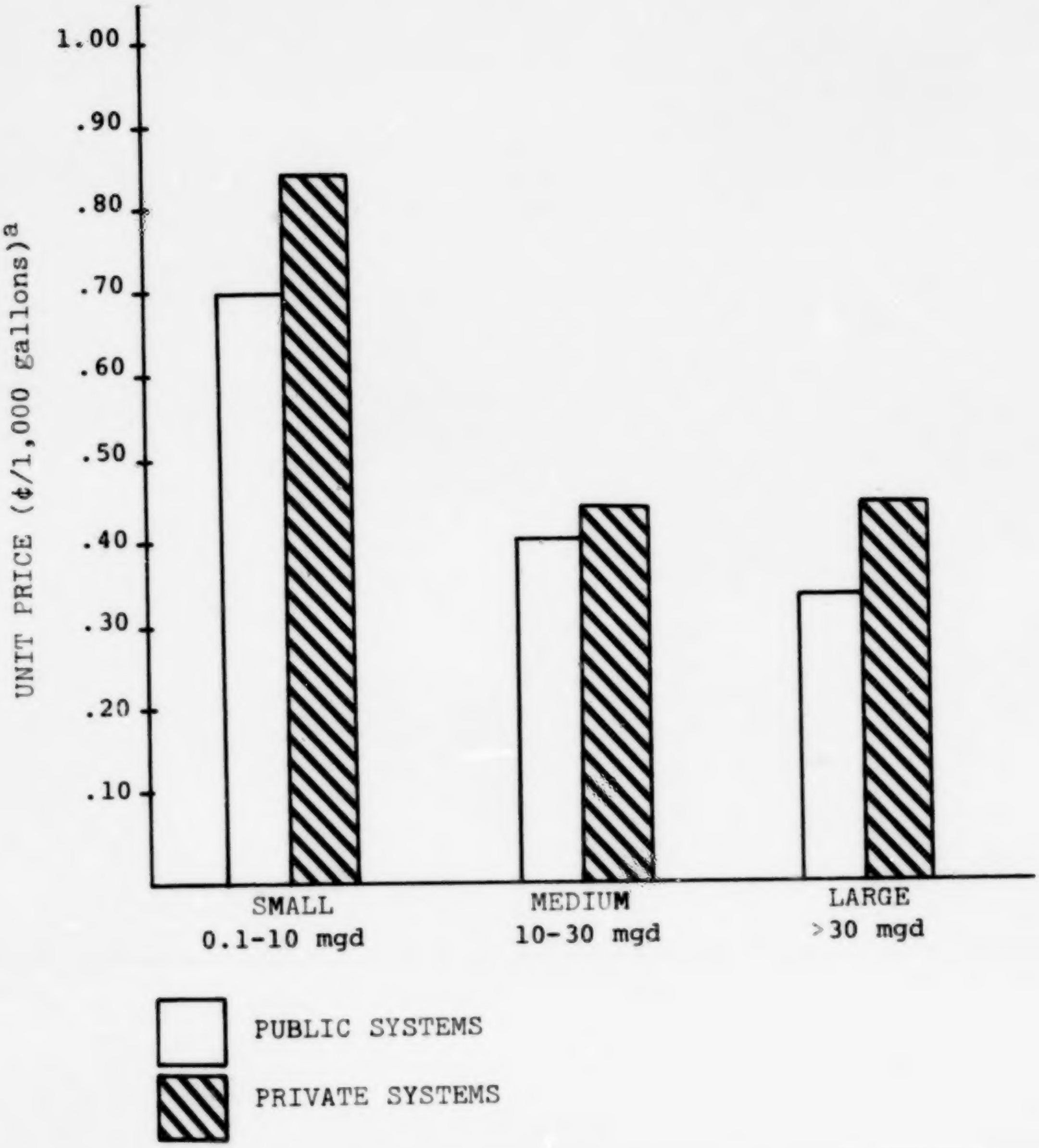
[1] National Sanitation Foundation, Staffing and Budgetary Guidelines for State Drinking Water Supply Agencies (Ann Arbor, Michigan, 1974).



[a] There are 0.00378 $m^3$ per gallon.

Figure 3-2. This figure shows the unit price of water in ¢/1,000 gallons.

TABLE 3-13

## ESTIMATED NUMBER OF PUBLIC NON-COMMUNITY WATER SUPPLY SYSTEMS BY STATE

| | POPULATION (x10³) | COLUMN 1 NUMBER | DATA SOURCE | COLUMN 2 NO. (ERCO SURVEY) |
|---|---|---|---|---|
| ALABAMA | 3,444 | 20,000 | | |
| ALASKA | 300 | 800 | CSSE | N |
| ARIZONA | 1,770 | 800 | CSSE | N |
| ARKANSAS | 1,923 | 1,350 | | |
| CALIFORNIA | 19,953 | 1,900 | | 3,000 |
| COLORADO | 2,207 | 1,300 | | N |
| CONNECTICUT | 3,031 | 1,200 | NSF est. | |
| DELAWARE | 548 | 401 | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | 6,789 | 2,716 | NSF est. | 5,000 |
| GEORGIA | 4,589 | 1,394 | | 1,000 |
| HAWAII | 768 | 9 | | N |
| IDAHO | 712 | 285 | NSF est. | 1,053 |
| ILLINOIS | 11,113 | 1,026 | | 4,600 |
| INDIANA | 5,193 | 10,185 | | 10,000 |
| IOWA | 2,824 | 615 | | N |
| KANSAS | 2,246 | 900 | NSF est. | 1,220 |
| KENTUCKY | 3,218 | 2,100 | | N |
| LOUISIANA | 3,641 | 2,000 | | |
| MAINE | 992 | 2,450 | | N |
| MARYLAND | 3,992 | 1,569 | NSF est. | 4,100 |
| MASSACHUSETTS | 5,889 | 2,276 | NSF est. | N |
| MICHIGAN | 8,875 | 15,731 | | 16,010 |
| MINNESOTA | 3,804 | 2,675 | | |
| MISSISSIPPI | 2,216 | 330 | | |
| MISSOURI | 4,676 | 8,100 | | |
| MONTANA | 894 | 1,700 | | N |
| NEBRASKA | 1,483 | 1,050 | | N |
| NEVADA | 488 | 779 | | |
| NEW HAMPSHIRE | 737 | 1,700 | | |
| NEW JERSEY | 7,168 | 5,200 | | N |
| NEW MEXICO | 1,016 | 2,000 | | N |
| NEW YORK | 18,236 | 36,000 | | N |
| NORTH CAROLINA | 5,082 | 4,333 | | N |
| NORTH DAKOTA | 617 | 250 | NFS est. | N |
| OHIO | 10,652 | 20,000 | | 19,100 |
| OKLAHOMA | 2,559 | 1,000 | | 4,000 |
| OREGON | 2,091 | 9,510 | | |
| PENNSYLVANIA | 11,793 | 23,945 | | 11,800 |
| RHODE ISLAND | 946 | 60 | | N |
| SOUTH CAROLINA | 2,590 | 1,552 | CSSE | 1,378 |
| SOUTH DAKOTA | 665 | 270 | | |
| TENNESSEE | 3,923 | 1,500 | | |
| TEXAS | 11,196 | 2,100 | | 10,150 |
| UTAH | 1,059 | 420 | CSSE | 505 |
| VERMONT | 444 | 3,300 | | 3,100 |
| VIRGINIA | 4,648 | 9,375 | | 9,400 |
| WASHINGTON | 3,409 | 2,500 | CSSE | 2,050 |
| WEST VIRGINIA | 1,744 | 18,010 | | 210 |
| WISCONSIN | 4,417 | 18,010 | | |
| WYOMING | 332 | 600 | CSSE | 426 |
| TOTAL | | 230,387 | | |

N is not known.
No entry indicates lack of response.

> any of the above. This estimate was made by assuming one system for each 2,500 population. The 2,500 factor was arrived at by taking the number of "Other Systems" reported for each state in the 1974 NSF survey, dividing it into the total population for that state, and then averaging the results.

Because the NSF survey was made in 1974, data from that questionnaire are used whenever they were available.

In addition, the results of a survey by ERCO in April 1975 pertinent to this category of public water supply systems is provided in Column 2 (see Appendix D for the ERCO survey). It becomes quite evident upon inspection of this table (particularly Texas) that accurate data on the number of non-community public water supply systems have not been compiled and more extensive state-by-state investigations will be necessary in this area.

Table 3-14 gives a breakdown by source of water for those systems where extensive data on water quality and system usage are available, while Table 3-15 provides a breakdown by source of water of systems found in the ERCO state survey. At the present time, the National Park Service is completing a national survey of all drinking water systems maintained by that service; however, it will be several months before the results of this study are known. Until the completion of the Park Service study, this sparse sample contains the only data which can be utilized to project national cost trends for the estimated 200,000 systems serving the travelling public.

TABLE 3-14

SOURCE OF WATER FOR 11 STUDIES OF PUBLIC NON-COMMUNITY WATER SYSTEMS*

| STUDY | SOURCE OF WATER<br>SURFACE | <br>GROUND | <br>PURCHASED | TOTAL |
|---|---|---|---|---|
| Bureau of Reclamation[a] | 28 | 25 | 5 | 58 |
| Water Resource[b] | 11 | 45 | 0 | 56 |
| Interstate[c] | 0 | 114 | 5 | 119 |
| Park Service[d] | 6 | 36 | 0 | 42 |
| Forest Service[e] | 26 | 93 | 0 | 119 |
| Kansas Evaluation[f] | 0 | 37 | 3 | 40 |
| Florida Evaluation[g] | 0 | 78 | 0 | 78 |
| Kentucky Evaluation[h] | 9 | 50 | 0 | 59 |
| Tennessee Evaluation[i] | 0 | 64 | 0 | 64 |
| Georgia Evaluation[j] | 0 | 81 | 0 | 81 |
| Wyoming Evaluation[k] | 1 | 12 | 0 | 13 |
| TOTAL | 81 | 635 | 13 | 729 |

*See following page for references.

[a] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems at Bureau of Reclamation Developments*, EPA-430/9-73-004, June 1973.

[b] U.S. Environmental Protection Agency, Office of Water Programs, *Sanitary Survey Of Drinking Water Systems on Federal Water Resource Developments, A Pilot Study*, August 1971.

[c] U.S. Environmental Protection Agency, Water Supply Division, *Drinking Water Systems On and Along the National System of Interstate and Defense Highways, A Pilot Study*, 1972.

[d] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems in the National Park Service System*, EPA-520/9-74-016, December 1974.

[e] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems in the U.S. Forest Service System*, November 1974.

[f] U.S. Environmental Protection Agency, Region VII, Water Supply Program, *Evaluation of the Kansas Water Supply Program*, 1972.

[g] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, *Evaluation of the Florida Water Supply Program*, 1973.

[h] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, *Evaluation of the Kentucky Water Supply Program*, May 1972.

[i] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, *Evaluation of the Tennessee Water Supply Program*, January 1971.

[j] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, *Evaluation of the Georgia Water Supply Program*, July 1973.

[k] U.S. Environmental Protection Agency, Region VIII, Water Supply Branch, *Evaluation of the Wyoming Water Supply Program*, December 1972.

## TABLE 3-5

## NUMBER OF NON-COMMUNITY SYSTEMS BY SOURCE

| | SURFACE WATER | GROUNDWATER |
|---|---|---|
| ALABAMA | | |
| ALASKA | N | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | N | N |
| COLORADO | N | 95 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 100 |
| HAWAII | N | N |
| IDAHO | 175 | 878 |
| ILLINOIS | 100 | 4,500 |
| INDIANA | N | 10,000 |
| IOWA | N | N |
| KANSAS | 20 | 1,200 |
| KENTUCKY | N | N |
| LOUISIANA | | |
| MAINE | N | N |
| MARYLAND | 2 | 4,100 |
| MASSACHUSETTS | N | N |
| MICHIGAN | 10 | 16,000 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | N |
| NEVADA | | |
| NEW HAMPSHIRE | N | |
| NEW JERSEY | N | N |
| NEW MEXICO | N | N |
| NEW YORK | N | N |
| NORTH CAROLINA | N | N |
| NORTH DAKOTA | N | N |
| OHIO | 100 | 19,000 |
| OKLAHOMA | 0 | 4,000 |
| OREGON | | |
| PENNSYLVANIA | 0 | 11,800 |
| RHODE ISLAND | N | N |
| SOUTH CAROLINA | 25 | 1,353 |
| SOUTH DAKOTA | 2 | 600 |
| TENNESSEE | | |
| TEXAS | 150 | 10,000 |
| UTAH | 5 | 500 |
| VERMONT | 100 | 3,000 |
| VIRGINIA | 0 | 9,400 |
| WASHINGTON | 50 | 2,000 |
| WEST VIRGINIA | N | 200 |
| WISCONSIN | | |
| WYOMING | 16 | 410 |
| TOTALS | 758 | 99,136 |

N is not known.
No entry indicates lack of response.

# CHAPTER FOUR

# DEVELOPMENT OF COSTS

## 4.0 Introduction

This chapter develops the projected national monitoring and treatment costs of the proposed regulations. The first section in this chapter develops all of the monitoring costs which would ensue from the implementation of the Proposed Interim Primary Drinking Water Regulations. The total monitoring costs are developed from the following six components:

1. Routine monitoring costs incurred by community water systems;
2. Costs incurred by community systems when maximum allowable limits are exceeded;
3. Costs incurred by community systems when the contaminant level is 75 percent or more of the maximum contaminant level;
4. Routine monitoring costs incurred by public water systems other than community systems;
5. Costs incurred by public non-community systems when maximum allowable limits are exceeded;
6. Costs incurred by public non-community systems when the contaminant level is 75 percent or more of the maximum contaminant level.

The analysis of monitoring costs shows that systems serving small populations vastly outnumber larger systems, and therefore assume the greatest share of monitoring costs while serving a very small percentage of the population. Figure 4-1 shows that 50 percent of the monitoring costs will be borne by 9 percent of the population, an indication that the costs of monitoring might be a burden on many of these smaller systems, and that some consideration ought to be given to decreasing their monitoring requirements.

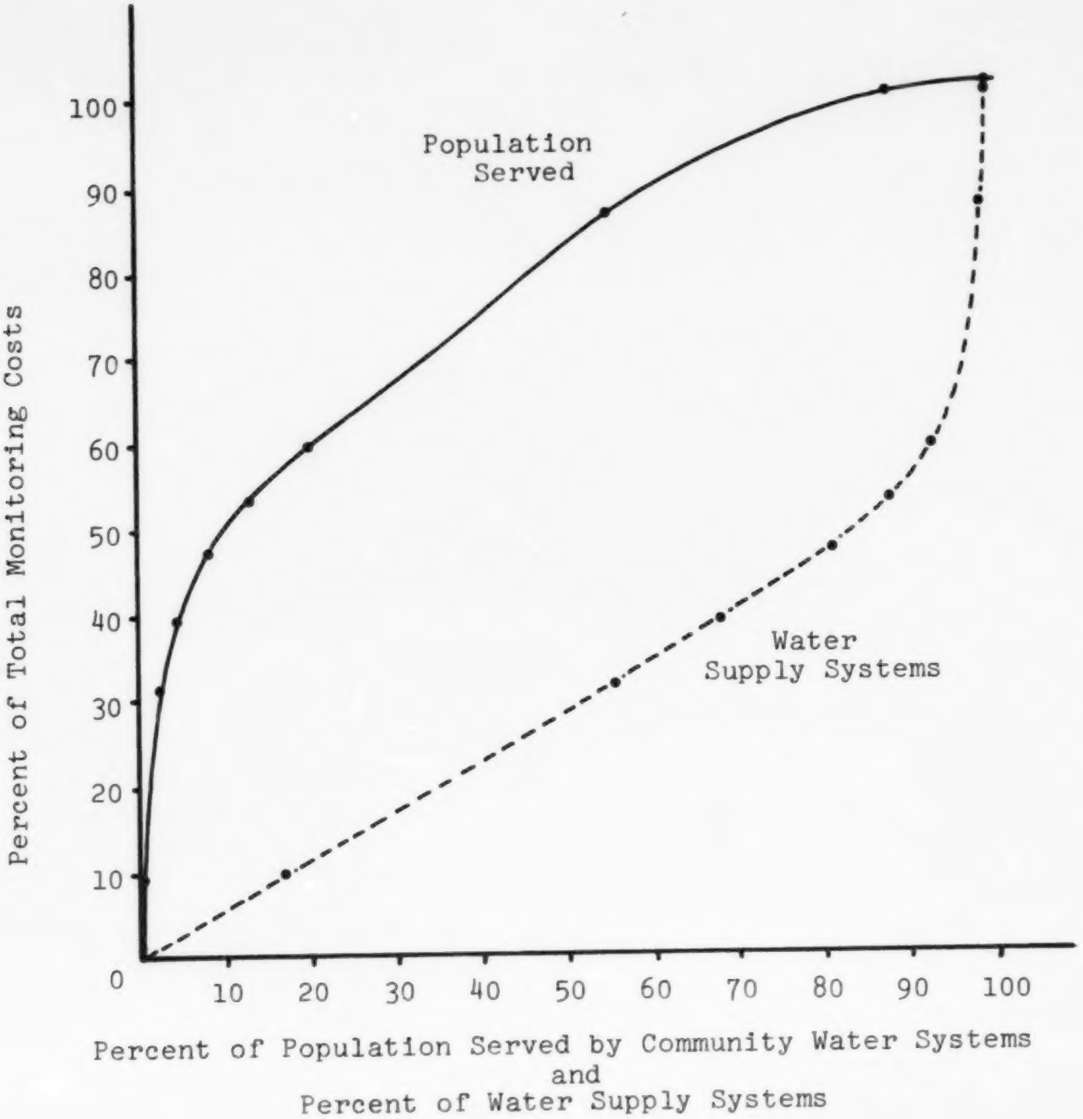


Figure 4-1. This figure shows the percentages of total monitoring costs in the United States versus the percentages of population served and the percentages of the water supply systems.

The second section in this chapter deals with treatment costs. Total treatment costs are developed from the following two components:

1. Treatment costs to be incurred by community water supply systems, grouped by treatment process and population size;

2. Treatment costs to be incurred by public non-community water supply systems, grouped by treatment process.

The analysis of treatment costs shows that operation and maintenance (O&M) and capital costs are spread equitably over the entire population served (Figure 4-2). The total capital costs for treatment would range between $1.1 and $1.8 billion spread over a 5-year period, while the O&M treatment costs would rise until an annual rate of $264 million was reached.

## 4.1 Monitoring Costs for Community Water Systems

This section develops the anticipated costs of chemical and biological monitoring for the estimated 40,000 community water systems in the United States. The Proposed Interim Primary Drinking Water Regulations (*Federal Register*, March 14, 1975), were used to establish monitoring frequencies in formulating these estimates. These regulations are synopsized in Table 4-1. Table 4-2 shows a breakdown of water systems by population served and by source of water.

The proposed regulations call for the monitoring of four classes of contamination: inorganic, organic, microbiological, and turbidity. Turbidity monitoring is not considered since this test must be done on-site and requires only manpower and a relatively inexpensive turbidimeter. (The manpower required for turbidity monitoring is considered in Chapter Five.) The monitoring frequencies for organics and inorganics depend on whether a given system derives its water from surface or ground sources. The numbers of systems estimated to be in these two categories are shown in Table 4-2. The sampling requirement for coliform and plate count monitoring depends on the size of the community served.

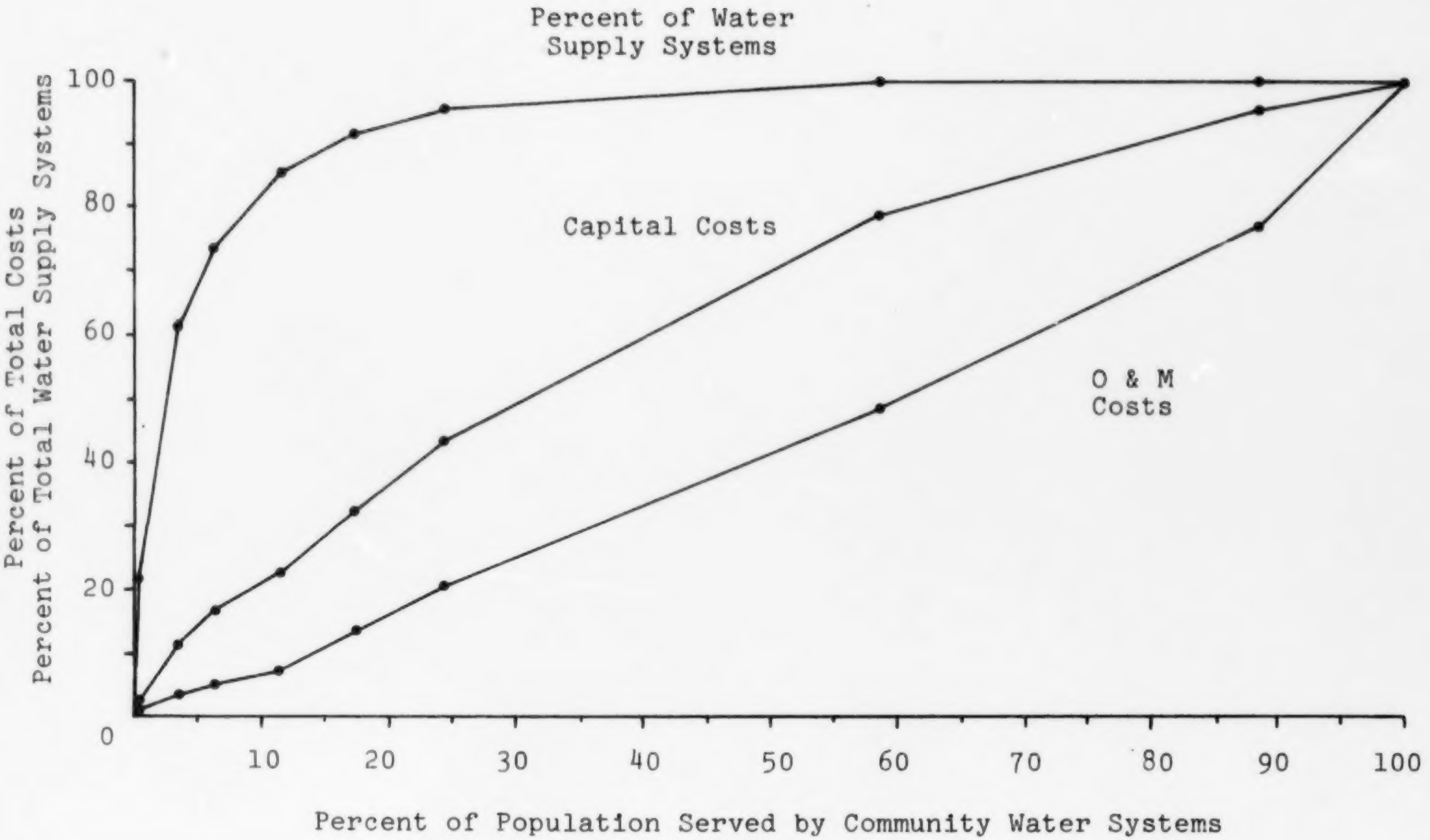


Figure 4-2. This figure shows the percentages of population served by community water systems versus percentages of total treatment costs.

TABLE 4-1

SUMMARY OF MONITORING REQUIREMENTS (EXCEPT TURBIDITY)

| SUBSTANCE | MAXIMUM LEVEL | REFERENCE METHOD[a] | MONITORING FREQUENCY |
|---|---|---|---|
| Arsenic | 0.05 | EPA 1974 pp. 95-96 | Community system supplied by surface water: initial tests to be performed within one year and repeated at yearly intervals.<br>Community system supplied by groundwater: initial tests within two years, then repeated at three year intervals.<br>Transient system: initial test within six years, then repeated at five year intervals.<br>Any component whose level exceeds 75% of maximum must be retested at one month intervals. These retests may be suspended if level remains below maximum for one year. Any component whose level exceeds maximum must be retested within 24 hours then weekly until level falls below maximum. |
| Barium | 1.0 | SMWW pp. 210-215 | |
| Cadmium | 0.010 | SMWW pp. 210-215 | |
| Chromium | 0.05 | SMWW pp. 210-215 | |
| Cyanide | 0.2 | EPA 1974 pp. 40-48 | |
| Lead | 0.05 | SMWW pp. 210-215 | |
| Mercury | 0.002 | EPA 1974 pp. 118-26 | |
| Nitrate | 10. | SMWW 213 pp. 461-464 | |
| Selenium | 0.01 | EPA 1974 pp. 145 | |
| Silver | 0.05 | SMWW pp. 210-215 | |
| Fluoride | 1.4 - 2.4 | SMWW pp. 172-174 | |
| Total Organic | 0.7 | JAWWA 65: 57, 197 (1973). | Community system supplied by surface water: initial test within 1 year, then repeated at yearly intervals.<br>Community system supplied by ground water: initial test within two years, then repeated at three year intervals.<br>Transient system: initial test within six years, then repeated at five year intervals.<br>Any component exceeding 75% or 100% of maximum to be retested as for inorganics. |
| Chlordane | 0.003 | EPA 1973 | |
| Endrin | 0.0002 | | |
| Heptachlor | 0.0001 | | |
| Heptachlor Epoxide | 0.0001 | | |
| Lindane | 0.004 | | |
| Methoxychlor | 0.1 | | |
| Toxaphene | 0.005 | | |
| 2,4-D | 0.1 | EPA 1973A | |
| 2,4,5-TP Silvex | 0.01 | | |
| Coliform (Membrane filter) | Av. 1 per 100 ml<br>Max. 4 per 100 ml | SMWW pp. 662-668 | Number of samples to be tested per month based on number of customers served. Either membrane filter or fermentation tube technique may be used. Sources of non-compliant samples must be retested daily until compliance achieved. |
| Coliform (Fermentation tube) | Max. 10% pos.: 10 ml samples<br>Max. 60% pos.: 100 ml samples | SMWW pp. 661-662 | |
| Coliform (Residual chlorine) | Min. 0.2 mg/l | SMWW pp. 120-132 | Daily or more frequent (depending on number of customers served) if substituted for either of the direct coliform methods. |
| Standard Plate Count | Max. 500 orgs./ml | SMWW pp. 660-662 | At least equal to 10% of coliform frequency with a minimum of 1 per month. |

[a] Abbreviations for references:

JAWWA = Journal of the American Water Works Association

SMWW = Standards Methods for the Examination of Water and Wastewater, 13th edition, 1971.

EPA 1973 = Methods for Determining Organic Pesticides in Water and Wastewater, EPA, Cincinnati, Ohio, 1971.

EPA 1974 = Methods for Chemical Analysis of Water and Wastes, EPA, Office of Technology Transfer, Washington, D.C., 1974.

EPA 1973A = Method for Organochlorine Pesticides in Industrial Effluents, MDQARL, EPA, Cincinnati, Ohio, 1973.

## TABLE 4-2

### DISTRIBUTION OF COMMUNITY WATER SYSTEMS BY POPULATION CLASS AND SOURCE OF WATER[a]

| | SOURCE OF WATER (NO. OF SYSTEMS) | | | | | | |
|---|---|---|---|---|---|---|---|
| POPULATION | SURFACE | GROUND | MIXED | PURCHASED | TOTAL NUMBER OF SYSTEMS | POPULATION SERVED | PER CAPITA DAILY PRODUCTION (GAL.)[b] |
| 25-99 | 275 | 6,361 | 56 | 316 | 7,008 | 420,500 | 99 |
| 100-499 | 946 | 12,947 | 199 | 1,021 | 15,113 | 3,778,250 | 109 |
| 500-999 | 548 | 4,278 | 144 | 422 | 5,392 | 3,774,400 | 118 |
| 1,000-2,499 | 857 | 3,690 | 281 | 354 | 5,182 | 7,773,000 | 132 |
| 2,500-4,999 | 625 | 1,607 | 189 | 184 | 2,605 | 8,857,000 | 140 |
| 5,000-9,999 | 468 | 1,079 | 169 | 142 | 1,858 | 12,634,400 | 154 |
| 10,000-99,999 | 767 | 1,243 | 274 | 315 | 2,599 | 61,423,400 | 158 |
| 100,000-999,999 | 108 | 63 | 52 | 13 | 236 | 57,277,200 | 174 |
| ≥1,000,000 | 5 | 0 | 2 | 0 | 7 | 21,523,600 | 192 |
| TOTAL | 4,599 | 31,268 | 1,366 | 2,767 | 40,000 | 177,470,750 | 165 |

[a] Based on EPA Survey of Community Water Supplies, as of July 1975.

[b] There are 0.00378 $m^3$ per gallon.

Laboratory costs were obtained in the following three ways:

1. A telephone survey of commercial laboratories in six states. This sample was further augmented by a follow-up written survey of commercial laboratories. The results of this survey are listed in Table 4-3;
2. A telephone survey of analytical costs estimated by the Environmental Protection Agency's Water Supply Research Laboratory in Cincinnati, Ohio (Tables 4-4, 4-5, and 4-6);
3. A survey of 207 plants which had failed at least one of the proposed mandatory regulations during the 1969 CWSS study. Of the 114 respondents to this survey, 23 used commercial laboratories for the analysis of their water samples (Appendix D). The rates charged these 23 supply systems were comparable with those found in Table 4-3.

According to EPA manpower data (Table 4-4), it would take approximately 5.1 hours for one man to do a complete inorganic sample (11 components). This means that one man can do approximately 32 complete analyses per month. If commercial overhead and G&A rates are applied, then the monthly cost for inorganic analyses is $4,025, or approximately $125 for a complete inorganic analysis (Table 4-5). For bacteriological analysis (Table 4-6) the monthly cost is $3,512 or $4.38 per sample. This $4.38 is exclusive of the cost of collecting and shipping samples to the laboratory. These figures are thus consistent with the range of commercial quotes ($5 to $20) for these same analyses as shown in Table 4-3. In determining government costs, overhead and G&A rates are not applicable; thus, the government cost for a complete inorganic analysis is approximately $78 and the cost for a bacteriological analysis is $2.63 exclusive of shipping costs.

In developing national monitoring cost estimates, the number of systems requiring routine monitoring is fixed by the number of ground- and surface-water supply systems in each size category (Table 4-2) and the monitoring frequency prescribed by the regulations (Appendix A). Therefore, the only variable in the cost development is the price per analysis. This price is dependent on the institutional monitoring arrangements made by each system. In this study, the lower monitoring cost is represented by the cost which EPA would incur in its laboratories, and the higher monitoring cost was calculated from the cost which would be charged by moderately expensive commercial laboratories.

## TABLE 4-3

## ANALYSIS OF DRINKING WATER SAMPLES: TYPICAL CHARGES BY COMMERCIAL LABORATORIES FOR ANALYSES SPECIFIED IN REGULATIONS

| LABORATORY: | A | B[a] | C | D | E[b] | F[c] | G | |
|---|---|---|---|---|---|---|---|---|
| LOCATION (STATE): | RI | FL | MA | MA | NJ | NM | NJ | RANGE |
| Gross Alpha and Beta | - | - | - | $15 | - | $20 | $12 | $12-20 |
| Strontium-89 and 90 | - | - | - | - | - | 80 | 45 | 45-80 |
| Tritium | - | - | - | - | - | 15-20 | 10 | 10-20 |
| Iodine-131 | - | - | - | - | - | 65 | | |
| Cesium-134 and 137 | - | - | - | - | - | 55, 80 | 65 | 65-155 |
| Potassium-40 | - | - | - | - | - | 10 | | |
| Coliform (Membrane filter) | $20 | $10 | $20 | 15, 10, 8[d] | - | - | - | 8-20 |
| (Fermentation tube) | 20 | - | - | 20, 15, 10[d] | - | - | - | 10-20 |
| Plate Count | 10 | 10 | 20 | 10, 6, 5[d] | - | - | - | 5-20 |
| Total Organic | - | 35-50 | 50 | - | $25 | - | - | 25-50 |
| Chlorinated Hydrocarbons | | 45[e] | 40 | 75 | 75, 125[f] | - | - | 40-305 |
| Organophosphates | 210 | 45[e] | 40 | -75 | 75, 125[f] | - | - | 40-180 |
| Chlorophenoxys | | 45[e] | 40 | -75 | 75, 100[f] | - | - | 40-80 |
| Arsenic | 28 | 20 | 12-20 | 15, 10[g] | 40 | - | - | 10-40 |
| Barium | 15 | 10 | 12-20 | 15, 10[g] | 15 | - | - | 10-20 |
| Cadmium | 10 | 15 | 12-20 | 15, 10[g] | 15 | - | - | 10-20 |
| Chromium | 10 | 10 | 12-20 | 15, 10[g] | 15 | - | - | 10-20 |
| Cyanide | 15 | 15 | 15-25 | 35, 15[g] | 35 | - | - | 15-35 |
| Lead | 10 | 10 | 12-20 | 15, 10[g] | 15 | - | - | 10-20 |
| Mercury | 20 | 15 | 12-20 | 20, 15[g] | 40 | - | - | 12-40 |
| Nitrate | 10 | 5 | 15-25 | 15, 12.50[g] | 23 | - | - | 5-25 |
| Selenium | 55 | 20 | 12-20 | 15, 10[g] | 40 | - | - | 10-55 |
| Silver | 10 | 15 | 12-20 | 15, 10[g] | 15 | - | - | 10-20 |
| Fluoride | 12 | 15 | 15-25 | 10, 8[g] | 23 | - | - | 8-25 |
| Inorganics - All Components | 195 | 155 | 150-250 | 185, 120.50[g] | 276 | - | - | 120-276 |

[a] A 5 percent discount on bills over $500.
A 10 percent discount on bills over $1,000.
A 15 percent discount on bills over $1,500.

[b] A 30 percent discount for six or more samples.

[c] Up to 20 percent discount available.

[d] Highest price is for single sample; middle for 2-10 samples; lowest for 11 or more samples.

[e] Price for scan plus one component analysis. Price for each additional component is $45.

[f] Higher price is for full analysis; lower price is for analysis of one specified component.

[g] Higher price is for single sample; lower for 2-10 samples.

## TABLE 4-4

## NUMBERS OF ANALYSES PER MAN-MONTH FOR SOME COMPONENTS OF PROPOSED INTERIM DRINKING WATER REGULATIONS[a]

| COMPONENT | NUMBER OF ANALYSES | TIME FOR ANALYSIS (man-hours) |
|---|---|---|
| ORGANIC SUBSTANCES | | |
| Total Organic (CCE) | 60 | 2.7 |
| Chlorinated Hydrocarbons and Herbicides | 18 | 8.9 |
| TOTAL ORGANIC | 14 | 11.6 |
| INORGANIC SUBSTANCES | | |
| Arsenic | 400 | 0.4 |
| Barium | 600 | 0.3 |
| Cadmium | 200 | 0.8 |
| Chromium | 600 | 0.3 |
| Cyanide | 200 | 0.8 |
| Lead | 200 | 0.8 |
| Nitrate | 600 | 0.3 |
| Selenium | 400 | 0.4 |
| Silver | 600 | 0.3 |
| Fluoride | 600 | 0.3 |
| Mercury | 400 | 0.4 |
| TOTAL INORGANIC | 32 | 5.1 |

[a] Personal communication E. McFarren, EPA, Cincinnati, Ohio, June 1975.

## TABLE 4-5

## MONTHLY BUDGET FOR ANALYSIS OF INORGANIC SAMPLES

| | |
|---|---|
| Salary | $1,000.00 |
| Salary Overhead (100% of salary) | 1,000.00 |
| Equipment Charge[a] | 1,000.00[b] |
| Expendable Supplies | 500.00 |
| Total Direct Cost | $3,500.00 |
| General and Administrative | 525.00 |
| Total Cost | $4,025.00 |
| Average Sample Cost[c] | $ 125.78 |

[a] Equipment includes two atomic absorption spectrometers, one equipped with a hydride generator, a cold vapor mercury analyzer, and a colorimeter.

[b] Five percent of retail figure of $20,000 for a monthly charge.

[c] This cost is exclusive of any sampling and shipping charges and is calculated by dividing the total costs by 32 inorganic analyses per month (Table 4-4).

## TABLE 4-6

## MONTHLY BUDGET FOR ANALYSIS OF BACTERIOLOGICAL SAMPLES[a]

| | |
|---|---|
| Salary | $1,000.00 |
| Salary Overhead | 1,000.00 |
| Equipment Charge[b] | 600.00 |
| Expendable Supplies | 500.00 |
| Total Direct Cost | $3,100.00 |
| General and Administrative | 412.50 |
| Total Cost | $3,512.50 |
| Average Sample Cost[c] | 4.38 |

[a] This budget is based on approximately 9,500 samples per man-year.

[b] Figured at 5 percent per man-month of $10,000 yearly cost for a one-man microbiological lab.

[c] Figured at 800 analyses per man-month.

The volume of coliform monitoring called for by the proposed interim regulations makes the cost of coliform determination the most critical component in determining the overall costs of routine monitoring. The cost range selected for coliform testing was $5 to $10. Table 4-7 gives cost ranges for routine monitoring of the 40,000 community systems. The costs in Table 4-7 assume no substitution of residual chlorine monitoring for coliform tests, a subject explored later in this section.

Since total monitoring costs are calculated on an annual basis, costs are divided evenly through the period in cases where the deadline for initial testing is greater than one year. (For example, for the 31,268 systems which are required to test for organics within 2 years of adoption, 15,634 are accounted for in the first year and the remaining 15,634 are put in the second.) Cases where the subsequent test intervals are greater than 1 year are handled in a similar manner.

One major factor which might reduce monitoring costs would be the substitution of residual chlorine testing for coliform counts. The Proposed Interim Primary Drinking Water Regulations require 30 residual chlorine tests to replace one coliform count. If one assumes a cost of $8.00 for each coliform count, then residual chlorine tests would have to be held below $0.27 to be cost-effective. Even the use of field-test kits would not be able to keep the costs of residual chlorine monitoring at this level.

In an effort to determine the number of water supply systems which would use the residual chlorine option instead of the coliform density measurement, ERCO surveyed (Appendix D) the 207 plants from the CWSS study. Of the 37 respondents to this question, 18 felt that they would probably use the residual chlorine option while 19 felt that they would definitely not use the option. In another survey of the 50 state water supply directors (Appendix B), ERCO asked if the states planned to encourage the use of chlorine residual monitoring to replace the coliform measurements. Of the 38 states responding as of May 22, 1975, 11 felt that they would encourage chlorine residual monitoring, 20 felt that they would discourage it, and 7 were undecided.

The total monitoring costs shown in Table 4-7 do not reflect the true impact of the imposition of the Proposed Interim Primary Drinking Water Regulations since much monitoring is presently being done under the Interstate Carrier Law and under existing state monitoring laws and therefore will not represent additional costs attributable to the proposed regulations.

TABLE 4-7

## COSTS OF ROUTINE MONITORING FOR THE COMMUNITY WATERWORKS

| | | | | | | | NUMBER OF TESTS (N) AND COSTS ($ MILLION) PER YEAR | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | FIRST YEAR | | SECOND YEAR | | THIRD & SUBSEQUENT YEARS | |
| COMPONENT | SYSTEM TYPE | | DEADLINE FOR INITIAL TESTING | SUBSEQUENT TEST INTERVALS | NUMBER OF SYSTEMS | ASSUMED COST PER TEST | N | $ MILLION | N | $ MILLION | N | $ MILLION |
| Inorganics | Surface[8] | | 1 yr. | 1 yr. | 5,965 | $78-188 | 5,965 | | 5,965 | | 5,965 | |
| | Ground | | 2 yr. | 3 yr. | 31,268 | $78-188 | 15,634 | | 15,634 | | 10,423 | |
| | Master Meter | | 1 yr. | 1 yr. | 2,767 | $78-188 | 2,767 | | 2,767 | | 2,767 | |
| INORGANICS TOTAL | | | | | 40,000 | | 24,366 | 1.9-4.6 | 24,366 | 1.9-4.6 | 19,155 | 1.5-3.6 |
| Organics | Surface | | 1 yr. | 1 yr. | 5,965 | $200-312 | 5,965 | | 5,965 | | 5,965 | |
| | Ground | | 2 yr. | 3 yr. | 31,268 | $200-312 | 15,634 | | 15,634 | | 10,423 | |
| | Master Meter | | 1 yr. | 1 yr. | 2,767 | $200-312 | 2,767 | | 2,767 | | 2,767 | |
| ORGANICS TOTAL | | | | | 40,000 | | 24,366 | 4.9-7.6 | 24,366 | 4.9-7.6 | 19,155 | 3.8-6.1 |
| Coliform: | 25 to 99 persons | | | 2/mo. | 7,008 | $ 5-10 | 168,192 | | 168,192 | | 168,192 | |
| | 100-499 | | | 2/mo. | 15,113 | $ 5-10 | 362,712 | | 362,712 | | 362,712 | |
| | 500-999 | | | 2/mo. | 5,392 | $ 5-10 | 129,408 | | 129,408 | | 129,408 | |
| | 1,000-2,499 | | | 2/mo. | 5,182 | $ 5-10 | 124,368 | | 124,368 | | 124,368 | |
| | 2,500-4,999 | Average 3,500 | | 4/mo. | 2,605 | $ 5-10 | 125,040 | | 125,040 | | 125,040 | |
| | 5,000-9,999 | " 6,800 | | 8/mo. | 1,858 | $ 5-10 | 178,368 | | 178,368 | | 178,368 | |
| | 10,000-24,999 | " 15,200 | | 17/mo. | 1,597 | $ 5-10 | 325,788 | | 325,788 | | 325,788 | |
| | 25,000-49,999 | " 34,300 | | 40/mo. | 677 | $ 5-10 | 324,960 | | 324,960 | | 324,960 | |
| | 50,000-99,999 | " 68,200 | | 75/mo. | 339 | $ 5-10 | 305,100 | | 305,100 | | 305,100 | |
| | 100,000-249,999 | " 148,600 | | 120/mo. | 155 | $ 5-10 | 223,200 | | 223,200 | | 223,200 | |
| | 250,000-499,999 | " 350,100 | | 180/mo. | 43 | $ 5-10 | 92,800 | | 92,800 | | 92,800 | |
| | 500,000-999,999 | " 735,000 | | 260/mo. | 24 | $ 5-10 | 74,880 | | 74,880 | | 74,880 | |
| | Over 1,000,000 | " 3,074,800 | | 450/mo. | 7 | $ 5-10 | 37,800 | | 37,800 | | 37,800 | |
| COLIFORM TOTAL | | | | | 40,000 | | 2,472,616 | 12.4-24.7 | 2,472,616 | 12.4-24.7 | 2,472,616 | 12.4-24.7 |
| Plate Count | 25 to 99 persons | | | 1/mo. | 7,008 | $ 5-10 | 84,096 | | 84,096 | | 84,096 | |
| | 100-499 | | | 1/mo. | 15,113 | $ 5-10 | 181,356 | | 181,356 | | 181,356 | |
| | 500-999 | | | 1/mo. | 5,392 | $ 5-10 | 64,704 | | 64,704 | | 64,704 | |
| | 1,000-2,499 | | | 1/mo. | 5,182 | $ 5-10 | 62,184 | | 62,184 | | 62,184 | |
| | 2,500-4,999 | | | 1/mo. | 2,605 | $ 5-10 | 31,260 | | 31,260 | | 31,260 | |
| | 5,000-9,999 | | | 1/mo. | 1,858 | $ 5-10 | 22,296 | | 22,296 | | 22,296 | |
| | 10,000-24,999 | | | 2/mo. | 1,597 | $ 5-10 | 38,328 | | 38,328 | | 38,328 | |
| | 25,000-49,999 | | | 4/mo. | 677 | $ 5-10 | 32,496 | | 32,496 | | 32,496 | |
| | 50,000-99,999 | | | 8/mo. | 339 | $ 5-10 | 32,544 | | 32,544 | | 32,544 | |
| | 100,000-249,999 | | | 12/mo. | 155 | $ 5-10 | 22,320 | | 22,320 | | 22,320 | |
| | 250,000-499,999 | | | 18/mo. | 43 | $ 5-10 | 9,288 | | 9,288 | | 9,288 | |
| | 500,000-999,999 | | | 26/mo. | 24 | $ 5-10 | 7,488 | | 7,488 | | 7,488 | |
| | Over 1,000,000 | | | 45/mo. | 7 | $ 5-10 | 3,780 | | 3,780 | | 3,780 | |
| PLATE COUNT TOTAL | | | | | 40,000 | | 592,140 | 3.0-5.9 | 592,140 | 3.0-5.9 | 592,140 | 3.0-5.9 |
| TOTAL PROJECTED MONITORING COSTS: 40,000 SYSTEMS | | | | | | | | 22.2-42.8 | | 22.2-42.8 | | 20.7-40.2 |

**ASSUMPTIONS:**

1. Additional tests not included for substances found to exceed 50, 75, or 100 percent of allowed standard limits.
2. Turbidity monitoring not included.
3. No allowance for the use of residual chlorine tests as substitute for coliform tests.
4. Lower costs based on EPA rates; higher costs based on commercial rates.
5. Coliform sampling frequency estimated from average size of works in each population chart.
6. For initial deadlines and test intervals greater than one year, costs are spread evenly throughout interval.
7. Assumed cost per test is derived from the range of commercial rates in Table 4-3.
8. Includes mixed systems.

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### 4.1.1 Monitoring of Water Systems at Present

A review was made of those interstate water systems which are also community water supplies, and are, therefore, currently subject to Federal purview under the interstate quarantine regulations of the Public Health Act. The populations served and water sources of these systems are shown in Table 4-8. However, an analysis of the monitoring practices of these systems showed that only the coliform measurements are taken at a rate commensurate with the Proposed Interim Primary Drinking Water Regulations. Other aspects of the proposed regulations, such as potential inorganic contaminants, organic quality of the water, and plate count measurements, are not presently subject to control.

The percentage of statewide coliform analyses performed in each state was used to determine the percentage of the required coliform monitoring being performed (Table 4-9). The average compliance rate for the 24 states responding was 58.7 percent, somewhat higher than the 37.3 percent compliance found in the 10 state drinking water evaluations. Included in this 58.7 percent (of the monitoring) are at least 655,391 samples which are being monitored for the interstate carrier systems. If these 655,391 samples are subtracted from the national total of 1,451,425 samples (2.47 million x 58.7 percent), this means that a total of 796,034 samples are being analyzed annually for the 34,380 non-interstate carrier systems. This is only 44 percent of the total samples which should be analyzed for these systems. Since these non-interstate systems serve mainly small populations, it is this group which would bear the majority of the additional monitoring costs. The estimated costs of the routine coliform measurements currently being performed are shown in Table 4-10. In this table the number of tests to be performed for the non-interstate carrier systems is 44 percent of the total number of expected analyses.

## 4.2 Costs Incurred by Community Water Systems When Maximum Contaminant Levels Are Exceeded

This section concerns the monitoring costs incurred by community water systems as a result of violating one or more of the Proposed Interim Primary Drinking Water Regulations as published in the Federal Register, March 14, 1975.

The special monitoring procedures mandated by the proposed regulations are listed in Table 4-11, while the

# TABLE 4-8

## INTERSTATE CARRIER WATER SUPPLIES WHICH ARE ALSO COMMUNITY WATER SUPPLIES

| POPULATION | SURFACE | SOURCE OF WATER<br>GROUND | MIXED | PURCHASED | TOTAL NUMBER OF SYSTEMS |
|---|---|---|---|---|---|
| 25-99 | 1 | 5 | 0 | 0 | 6 |
| 100-499 | 1 | 11 | 1 | 0 | 13 |
| 500-999 | 4 | 5 | 0 | 2 | 11 |
| 1,000-2,499 | 6 | 11 | 2 | 0 | 19 |
| 2,500-4,999 | 10 | 11 | 3 | 3 | 27 |
| 5,000-9,999 | 25 | 17 | 6 | 3 | 51 |
| 10,000-99,999 | 138 | 67 | 47 | 24 | 276 |
| 100,000-999,999 | 86 | 35 | 42 | 3 | 166 |
| > 1,000,000 | 5 | 0 | 2 | 0 | 7 |
| TOTAL | 276 | 162 | 103 | 35 | 576 |

## TABLE 4-9

## COLIFORM ANALYSES BY STATE

| STATE | 1<br># OF COMMUNITY SYSTEMS[a,b] | 2<br>% OF TOTAL ANALYSES[b] IN STATE LABS | 3<br># OF ANALYSES[b] IN STATE LABORATORIES | 4<br>TOTAL # OF ANALYSES[c] IN STATE | 5<br>PROJECTED # OF ANALYSES IN STATE[d] | 6<br>% of COMPLIANCE[e] | % OF SYSTEMS IN COMPLIANCE IN STATE EVALUATIONS |
|---|---|---|---|---|---|---|---|
| Alabama | [503] | - | - | - | - | - | - |
| Alaska | [69] | 90 | N.A. | - | - | - | - |
| Arizona | [1,912*] | 100 | N.A. | - | - | - | - |
| Arkansas | [500] | - | - | - | - | - | - |
| California | 4,100 | N.A. | 13,000 | - | - | - | - |
| Colorado | - | 49 | 9,800 | 20,000 | 50,400 | 40 | 40 |
| Connecticut | [395] | N.A. | N.A. | - | - | - | 29 |
| Delaware | [139] | - | - | - | - | - | - |
| Dist. of Columbia | - | - | - | - | - | - | - |
| Florida | [1,800] | N.A. | N.A. | - | - | - | 30 |
| Georgia | 2,630 | 90 | 40,000 | 44,444 | 189,360 | 23 | 45 |
| Hawaii | 125* | 40 | 5,953 | 14,882 | 9,000 | 100+ | - |
| Idaho | 957 | 98 | 7,191 | 7,337 | 68,904 | 11 | 32 |
| Illinois | [1,620] | 80 | 72,000 | 90,000 | 116,640 | 77 | - |
| Indiana | 463 | 80 | 25,648 | 32,060 | 33,336 | 96 | - |
| Iowa | 822 | 50 | 40,000 | 80,000 | 59,184 | 100+ | - |
| Kansas | [illegible] | 99 | 45,649 | - | - | - | 48 |
| Kentucky | [500] | 70 | 21,000 | 30,000 | 36,000 | 83 | 36 |
| Louisiana | [600] | - | - | - | - | - | - |

[a] Numbers in brackets from 1974 Staffing and Budgetary Guidelines for State Drinking Water Agencies by the National Sanitation Foundation.

[b] Information supplied by states in April 1975 ERCO questionnaire.

[c] Determined by dividing Column 3 by Column 2.

[d] Determined by multiplied Column 1 by 72, the national average of coliform tests per system per year.

[e] Column 4 divided by Column 5.

## TABLE 4-9 (CONT.)

## COLIFORM ANALYSES BY STATE

| STATE | 1<br># OF COMMUNITY SYSTEMS[a,b] | 2<br>% OF TOTAL ANALYSES[b] IN STATE LABS | 3<br># OF ANALYSES[b] IN STATE LABORATORIES | 4<br>TOTAL # OF ANALYSES[c] IN STATE | 5<br>PROJECTED # OF ANALYSES IN STATE[d] | 6<br>% COMPLIANCE[e] | % OF SYSTEMS IN COMPLIANCE IN STATE EVALUATIONS |
|---|---|---|---|---|---|---|---|
| Maine | 170 | 90 | 10,000 | 11,111 | 12,240 | 91 | - |
| Maryland | [790] | 67 | 14,000 | 20,895 | 56,880 | 37 | - |
| Massachusetts | 2,216 | N.A. | N.A. | - | - | - | - |
| Michigan | [1974] | 18 | 24,000 | 133,333 | 142,128 | 94 | - |
| Minnesota | [680] | - | - | - | - | - | - |
| Mississippi | [2,100] | - | - | - | - | - | - |
| Missouri | [923] | - | - | - | - | - | - |
| Montana | [221] | N.A. | N.A. | - | - | - | - |
| Nebraska | 460 | 70 | N.A. | - | - | - | - |
| Nevada | [93] | - | - | - | - | - | - |
| New Hampshire | [325] | - | - | - | - | - | - |
| New Jersey | 496 | N.A. | N.A. | - | - | - | - |
| New Mexico | 370 | 100 | 25,000 | 25,000 | 26,640 | 94 | - |
| New York | 1,535 | - | - | - | - | - | - |
| North Carolina | 2,707 | 75 | 40,000 | 53,333 | 194,904 | 27 | - |
| North Dakota | 257 | <90 | 7,000 | 7,777 | 18,504 | 42 | - |
| Ohio | 1,652 | 90 | 45,000 | 50,000 | 118,944 | 42 | 33 |
| Oklahoma | [860] | 46 | 41,000 | 89,130 | 61,920 | 100+ | - |

[a] Numbers in brackets from 1974 Staffing and Budgetary Guidelines for State Drinking Water Agencies by the National Sanitation Foundation.

[b] Information supplied by states in April 1975 ERCO questionnaire.

[c] Determined by dividing Column 3 by Column 2.

[d] Determined by multiplied Column 1 by 72, the national average of coliform tests per system per year.

[e] Column 4 divided by Column 5.

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## TABLE 4-9 (CONT.)

## COLIFORM ANALYSES BY STATE

| STATE | 1<br># OF COMMUNITY SYSTEMS[a,b] | 2<br>% OF TOTAL ANALYSES[b] IN STATE LABS | 3<br># OF ANALYSES[b] IN STATE LABORATORIES | 4<br>TOTAL # OF ANALYSES[c] IN STATE | 5<br>PROJECTED # OF ANALYSES IN STATE[d] | 6<br>% COMPLIANCE[e] | % OF SYSTEMS IN COMPLIANCE INSTATE EVALUATIONS |
|---|---|---|---|---|---|---|---|
| Oregon | [590] | - | - | - | - | - | - |
| Pennsylvania | 4,375 | N.A. | 2,609 | - | - | - | - |
| Rhode Island | 52 | N.A. | 6,870 | - | - | - | - |
| South Carolina | 1,270 | 32 | 50,000 | 156,250 | 91,440 | 100+ | - |
| South Dakota | 371 | 90 | 15,000 | 16,667 | 26,712 | 62 | - |
| Tennessee | [520] | - | - | - | - | - | 46 |
| Texas | 6,900 | 90 | 260,322 | 289,246 | 496,800 | 58 | - |
| Utah | 665 | 60 | 20,000 | 33,333 | 47,880 | 70 | - |
| Vermont | 371 | 100 | 20,000 | 20,000 | 26,712 | 75 | - |
| Virginia | 1,353 | 80 | 84,520 | 105,650 | 97,416 | 100+ | - |
| Washington | 1,600 | 40 | 15,000 | 37,500 | 115,200 | 33 | - |
| West Virginia | 650 | 70 | N.A. | - | - | - | - |
| Wisconsin | [600] | - | - | - | - | - | - |
| Wyoming | 424 | 99 | 7,575 | 7,651 | 30,528 | 25 | 34 |
|  |  |  |  | 1,248,647[f] | 2,127,672 | 58.7 |  |

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[a] Numbers in brackets from 1974 Staffing and Budgetary Guidelines for State Drinking Water Agencies by the National Sanitation Foundation.

[b] Information supplied by States in April, 1975 ERCO questionnaire.

[c] Determined by dividing Column 3 by Column 2.

[d] Determined by multiplying Column 1 by 72, the national average of coliform tests per system per year.

[e] Column 4 divided by Column 5.

[f] No more than 100 percent compliance per state was counted.

TABLE 4-10

PRESENT COSTS FOR COLIFORM MONITORING OF INTERSTATE CARRIER WATER SYSTEMS

| | | | | NUMBER OF INTERSTATE SYSTEMS | NUMBER OF TESTS | COST PER YEAR ($ million) |
|---|---|---|---|---|---|---|
| COLIFORM: | 25-99 persons | Average | 47 | 6 | 144 | |
| | 100-499 | " | 178 | 13 | 312 | |
| | 500-999 | " | 604 | 11 | 264 | |
| | 1,000-2,499 | " | 1,741 | 19 | 456 | |
| | 2,500-4,999 | " | 4,258 | 27 | 1,620 | |
| | 5,000-9,999 | " | 6,413 | 51 | 4,284 | |
| | 10,000-99,999 | " | 43,349 | 276 | 165,600 | |
| | 100,000-999,999 | " | 449,528 | 166 | 398,400 | |
| | > 1,000,000 | " | 3,074,800 | 7 | 37,800 | |
| COLIFORM TOTAL FOR 576 INTERSTATE SYSTEMS | | | | | 608,880 | 3.0-6.1 |
| COLIFORM TCTAL FOR 39,424 NON-INTERSTATE SYSTEMS | | | | | 842,545 | 4.3-8.3 |
| TOTAL PRESENT COLIFORM MONITORING FOR 40,000 SYSTEMS | | | | | | 7.3-14.4 |

## TABLE 4-11

## MONITORING REQUIREMENTS WHEN MAXIMUM CONTAMINANT LEVEL IS EXCEEDED

| CONTAMINANT | Mandated Monitoring Requirements. |
|---|---|
| COLIFORM | Collect and analyze daily samples from same sampling point where violation occurred until at least two consecutive samples show no positive coliform results. |
| INORGANICS AND PESTICIDES | Repeat analysis within 24 hours, then weekly during the period of time the maximum contaminant level is exceeded. To determine compliance of a public water system with the maximum contaminant levels either 12 month, 3 month, or 1 month moving averages shall be used. |
| ORGANICS | Repeat the analyses within two weeks of initial analysis. |

number of systems found to be in violation of maximum contaminant levels in the CWSS survey of 969 systems is shown in Table 4-12. In the CWSS study, 90 percent of those systems in violation served fewer than 5,000 people.

The costs of special monitoring for coliform violations are estimated in Table 4-13. The proposed regulations call for daily coliform testing in each location where a sample violation occurs until the violation is corrected. For purposes of estimation it is assumed that between 7 and 30 coliform analyses will be performed for each coliform violation found. This would allow for finding and correcting the cause of the violation. Note that special monitoring for coliform is required for each sample, not for each system.

The costs of special monitoring for chemical violations are shown in Table 4-14. The number of violations shown for mercury is estimated under the assumption that 2.7 percent of the systems exceed the standard for mercury. The proposed regulations call for weekly testing of each chemical contaminant found to be in excess of regulations until such time as the regulations are met, or until a variance is granted. This would result in a sampling requirement of between 8 and 52 samples for each violating system.

It is important to realize that once the cause of the violation is located and treatment commences, no further special monitoring costs should occur. One exception, however, to this rule would be monitoring for coliform organisms, since these violations can be spurious in nature; however, it is assumed that a well-run chlorination treatment will be effective in controlling coliform contamination. Therefore, it is anticipated that the majority of these special monitoring costs would be incurred during the first few years of implementation of the Act. Except in isolated instances of small population areas (and major contamination problems), special monitoring will not prove unduly burdensome.

## 4.3 Special Monitoring Required of Community Water Systems When Chemical Contaminants Are Found to Be Between 75 and 100 Percent of Maximum Levels

Any water system in which the concentration of a chemical contaminant is between 75 and 100 percent of the maximum contaminant level is required to monitor monthly for that contaminant for one year. If none of the 12 readings is above the maximum contaminant level, the monthly monitoring may be suspended.

TABLE 4-12

SYSTEMS WHICH EXCEEDED ONE OR MORE MAXIMUM CONTAMINANT LEVEL BROKEN DOWN BY POPULATION SERVED[a]

| POPULATION SERVED | As | Ba | Cd | Cr | CN | Pb | $NO_3$ | Se | Ag | F | CCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 0 | 0 | 0 | 2 | 0 | 4 | 5 | 2 | 0 | 5 | 0 |
| 100-499 | 1 | 0 | 2 | 0 | 0 | 6 | 8 | 5 | 0 | 18 | 0 |
| 500-999 | 2 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 3 | 1 |
| 1,000-2,499 | 0 | 1 | 1 | 0 | 0 | 3 | 2 | 0 | 0 | 3 | 1 |
| 2,500-4,999 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 2 | 1 |
| 5,000-9,999 | 0 | 0 | 0 | 0 | 0 | 2 | 3 | 0 | 0 | 4 | 1 |
| 10,000-99,999 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 100,000-999,999 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| > 1,000,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 3 | 1 | 4 | 3 | 0 | 16 | 22 | 9 | 0 | 36 | 5 |

[a] From CWSS study.

## TABLE 4-13

## SPECIAL MONITORING COSTS FOR COLIFORM VIOLATIONS

| | |
|---|---|
| Number of tests required for each sample in violation | 7-30 |
| Estimated cost per test[a] | \$5-\$10 |
| Percent of samples in violation, CWSS survey | 0.88% |
| Total cost for violations, 40,000 systems[b] (\$ million) | \$0.7-\$6.5 |

[a] Same as one used for routine monitoring costs.

[b] Assumes CWSS analysis results hold nationwide and that once a violation is found in the system, treatment will commence and no further violations will occur in that system.

TABLE 4-14

SPECIAL MONITORING COSTS FOR CHEMICAL VIOLATIONS

| CONTAMINANT | PERCENT OF CWSS SYSTEMS EXCEEDING MCL[a] | NUMBER OF SYSTEMS PROJECTED TO BE IN VIOLATION[b] | NUMBER OF TESTS REQUIRED (1 Year) | COST PER TEST[c] ($) | TOTAL COST ($ thousand) |
|---|---|---|---|---|---|
| Arsenic | 0.42G | 131 | 8-52 | 7.7-18.5 | 8.1-126.0 |
| Barium | 0.14G | 44 | 8-52 | 7.7-18.5 | 2.7-42.3 |
| Cadmium | 0.56G | 175 | 8-52 | 7.7-18.5 | 10.8-168.3 |
| Chromium | 0.42G | 131 | 8-52 | 5.6-13.5 | 5.9-92.0 |
| Cyanide | 0 | 0 | 8-52 | 7.7-18.5 | 0 |
| Lead | 0.43G<br>2.1 S | 227 | 8-52 | 5.6-13.5 | 10.2-159.4 |
| Mercury[d] | 1.35G<br>1.35S | 483 | 8-52 | 11.6-28.0 | 44.8-703.2 |
| Nitrate | 3.1 G | 969 | 8-52 | 5.6-13.5 | 43.4-680.2 |
| Selenium | 1.13G<br>0.44S | 373 | 8-52 | 7.7-18.5 | 23.0-358.8 |
| Silver | 0 | 0 | 8-52 | 5.6-13.5 | 0 |
| Fluoride | 5.0G | 1,563 | 8-52 | 5.6-13.5 | 70.0-109.7 |
| CCE[e] | 3.42S | 158 | 8-52 | 45.0-70 | 56.8-575.1 |
| TOTAL FOR 40,000 SYSTEMS, NATIONWIDE[b,c] | | | | | 257.7-3,015.0 |

[a] In CWSS sample of 969 systems based on surface (S) or groundwater (G) source.

[b] Projected from CWSS data base by source of water.

[c] Low cost based on EPA laboratory rates, high cost based on commercial rates.

[d] No data in CWSS -- number estimated from interstate carrier and other state data.

[e] Carbon chloroform extract.

This section deals with the costs of such monitoring for community systems. It is assumed that the CWSS survey contains data representative for the nation and that no violations (above maximum contaminant levels) were found (Table 4-15). The costs of this special monitoring for chemicals are shown in Table 4-16. The number of near-violations for mercury is estimated from 10 state studies, since the CWSS study did not analyze for mercury. As in the previous section, cost ranges were developed from EPA and commercial laboratory rates.

The proposed interim regulations state that if after one year of monthly monitoring the level of the contaminant is stable and due to a natural condition of the water source, the water supplier may reduce the frequency of monitoring to one analysis per year. This means that most of the costs incurred to monitor systems with contaminant levels between 75 and 100 percent of the MCL would be borne for one year only. Those systems which are found to exceed the maximum limit would be forced to implement corrective action to eliminate the violation. Table 4-17 shows the relative magnitude of all monitoring costs for community systems.

## 4.4 Costs for Monitoring of Water Systems Serving Transient Populations (Non-Community Systems)

This section develops the routine monitoring costs for one typical water system serving a transient population, and the results are used to estimate the nationwide costs for routine monitoring.

It is assumed that the typical system serves an average population of between 25 and 2,500 persons daily throughout the year. The upper limit ensures that only the minimum number of coliform tests (2 per month) and plate counts (1 per month) need be run. The lower limit ensures that the system is covered by the regulations. Year-round use sets the annual number of coliform samples at 24. Seasonal shutdown would decrease the coliform sampling requirement, while a large water system (serving, for example, a national park or an airport) would be required to submit more samples. For purposes of estimating the routine monitoring costs for the approximately 200,000 water systems nationwide which serve transient populations, it is assumed that no system will shut down as an alternative to routine monitoring. The cost figures for the individual tests are the same that were used

## TABLE 4-15

## SYSTEMS WHICH ARE BETWEEN 75 AND 100 PERCENT OF MAXIMUM CONTAMINANT LEVEL BROKEN DOWN BY POPULATION SERVED

| POPULATION SERVED | As | Ba | Cd | Cr | CN | Pb | $NO_3$ | Se | Ag | F | CCE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 1 | 0 | 1 | 7 | 0 | 7 | 0 | 3 | 0 | 24 | 0 |
| 100-499 | 0 | 0 | 2 | 6 | 0 | 11 | 6 | 5 | 0 | 4 | 0 |
| 500-999 | 0 | 0 | 0 | 5 | 0 | 7 | 4 | 6 | 0 | 7 | 0 |
| 1,000-2,499 | 0 | 0 | 0 | 2 | 0 | 6 | 1 | 6 | 0 | 3 | 2 |
| 2,500-4,999 | 0 | 0 | 0 | 2 | 0 | 5 | 3 | 5 | 0 | 2 | 0 |
| 5,000-9,999 | 0 | 0 | 0 | 3 | 0 | 1 | 4 | 0 | 0 | 2 | 1 |
| 10,000-99,999 | 0 | 0 | 0 | 3 | 0 | 6 | 3 | 6 | 0 | 2 | 1 |
| 100,000-999,999 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 5 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 1 | 0 | 3 | 28 | 0 | 45 | 22 | 36 | 0 | 44 | 4 |

TABLE 4-16

SPECIAL MONITORING REQUIRED WHEN CHEMICAL CONTAMINANT LEVELS ARE FOUND TO BE BETWEEN 75 AND 100 PERCENT OF MAXIMUM LEVELS (COMMUNITY WATER SYSTMES)

| CONTAMINANT | PERCENT OF CWSS SYSTEMS BETWEEN 75%-100% OF MCL[a] | NUMBER OF SYSTEMS PROJECTED TO BE 75%-100% OF MCL[b] | NUMBER OF TESTS REQUIRED (1 Year) | COST PER TEST[c] ($) | TOTAL COST ($ thousand) |
|---|---|---|---|---|---|
| Arsenic | 0.14G | 44 | 12 | 7.7-18.5 | 4.1-9.8 |
| Barium | | 0 | 12 | 7.7-18.5 | 0 |
| Cadmium | 5.0 G | 1,563 | 12 | 7.7-18.5 | 144.4-347.0 |
| Chromium | 3.9 G | 1,219 | 12 | 5.6-13.5 | 81.9-197.4 |
| Cyanide | | 0 | 12 | 7.7-18.5 | 0 |
| Lead | 4.35S<br>4.9 G | 1,732 | 12 | 5.6-13.5 | 116.4-280.6 |
| Mercury[d] | 4.0 S<br>4.0 G | 1,435 | 12 | 11.6-28.0 | 199.7-482.2 |
| Nitrate | 3.1 G | 969 | 12 | 5.6-13.5 | 65.1-157.0 |
| Selenium | 6.6 S<br>10.6 G | 3,617 | 12 | 7.7-18.5 | 334.2-803.0 |
| Silver | | 0 | 12 | 5.6-13.5 | 0 |
| Fluoride | 6.2 G | 1,939 | 12 | 5.6-13.5 | 130.3-314.1 |
| CCE[e] | 2.7 S | 124 | 12 | 45-70 | 67.0-104.2 |
| TOTAL FOR 40,000 SYSTEMS, NATIONWIDE, ONE YEAR | | | | | 1,143.1-2,695.2 |

[a] In CWSS sample of 969 systems based on surface (S) or groundwater (G) source.

[b] Projected from CWSS data base by source of water.

[c] Low cost based on EPA laboratory rates, high cost based on commercial rates.

[d] No data in CWSS -- number estimated from 10 state drinking water evaluations.

[e] Carbon chloroform extract.

TABLE 4-17

MONITORING COSTS FOR COMMUNITY SYSTEMS
($ million)

| | |
|---|---|
| Routine monitoring costs | 22.2 - 42.8 |
| Monitoring for systems 75 and 100 percent of maximum contaminant level | 1.1 - 2.7 |
| Monitoring for systems which exceed the maximum contaminant level | 0.9 - 8.4 |

to estimate routine monitoring costs for community systems. Again, the most critical cost component is that of coliform monitoring. Table 4-18 shows the total number of non-community systems broken down by source. (Non-community systems need not monitor for turbidity if their source is groundwater.) The costs for routine monitoring are shown in Table 4-19.

It is estimated that, at present, no more than 5 percent of the required coliform testing is being performed, and virtually no other chemical or biological testing is taking place. This 5 percent coliform testing amounts to between $1.2 and $2.4 million a year.

## 4.5 Costs Incurred by Non-Community Systems When Maximum Allowable Limits Are Exceeded

The data on violations used in this analysis were developed from 11 separate studies of Federal and state "semi-public" water supply systems which serve the travelling public. Using these studies to extrapolate national cost figures is very difficult, since these Federal systems often have more treatment facilities than non-Federal systems. In addition, these systems are not representative of the national distribution of water by source. However, since these are the only water quality data presently available on these systems, they are used despite the dubious quality of the extrapolated results. Table 4-20 lists the number of systems which exceeded one or more maximum contaminant levels for public non-community systems, while Tables 4-21 and 4-22 show the costs of monitoring these systems for coliform and chemical violations.

## TABLE 4-18

## NUMBER OF NON-COMMUNITY WATER SYSTEMS BY SOURCE

| | SURFACE WATER | GROUNDWATER |
|---|---|---|
| ALABAMA | | |
| ALASKA | N | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | N | N |
| COLORADO | N | 95 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 100 |
| HAWAII | N | N |
| IDAHO | 175 | 878 |
| ILLINOIS | 100 | 4,500 |
| INDIANA | N | 10,000 |
| IOWA | N | N |
| KANSAS | 20 | 1,200 |
| KENTUCKY | N | N |
| LOUISIANA | | |
| MAINE | N | N |
| MARYLAND | 2 | 4,100 |
| MASSACHUSETTS | N | N |
| MICHIGAN | 10 | 16,000 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | N |
| NEVADA | | |
| NEW HAMPSHIRE | N | |
| NEW JERSEY | N | N |
| NEW MEXICO | N | N |
| NEW YORK | N | N |
| NORTH CAROLINA | N | N |
| NORTH DAKOTA | N | N |
| OHIO | 100 | 19,000 |
| OKLAHOMA | 0 | 4,000 |
| OREGON | | |
| PENNSYLVANIA | 0 | 11,800 |
| RHODE ISLAND | N | N |
| SOUTH CAROLINA | 25 | 1,353 |
| SOUTH DAKOTA | 2 | 600 |
| TENNESSEE | | |
| TEXAS | 150 | 10,000 |
| UTAH | 5 | 500 |
| VERMONT | 100 | 3,000 |
| VIRGINIA | 0 | 9,400 |
| WASHINGTON | 50 | 2,000 |
| WEST VIRGINIA | N | 200 |
| WISCONSIN | | |
| WYOMING | 16 | 410 |
| TOTALS | 758 | 99,136 |

N is not known.
No entry indicates lack of response.

## TABLE 4-19

## COSTS OF ROUTINE MONITORING FOR WATER SYSTEMS SERVING NON-COMMUNITY POPULATIONS ACCORDING TO THE PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

| CONTAMINANT | DEADLINE FOR INITIAL TESTING | SUBSEQUENT TEST INTERVALS | ASSUMED COST PER TEST ($) | COST PER YEAR FIRST 5 YEARS ($) | COST PER YEAR SUBSEQUENT YEARS ($) |
|---|---|---|---|---|---|
| Inorganics | 5 years | 6 years | 78-188 | 15.6-37.6 | 13.0-31.3 |
| Organics and Pesticides | 5 years | 6 years | 200-312 | 40.0-62.4 | 33.3-52.0 |
| Plate Count | 1 year | 1 per month | 5-10 | 60.0-120.0 | 60.0-120.0 |
| Coliform | None | 2 per month | 5-10 | 120.0-240.0 | 120.0-240.0 |
| Monitoring costs per year per system | | | | 235.6-460.0 | 226.3-443.3 |
| Monitoring costs per year, nationwide (200,000 systems) ($ million) | | | | 47.1- 92.0 | 45.3- 88.7 |

## TABLE 4-20

### NUMBER OF PUBLIC NON-COMMUNITY SYSTEMS WHICH EXCEEDED ONE OR MORE MAXIMUM CONTAMINANT LEVELS AS SPECIFIED IN THE INTERIM PRIMARY DRINKING WATER REGULATIONS*

| STUDY | CONTAMINANT | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Ag | $NO_3$ | CR | Coliform | Se | F | Pb | Hg | Cd |
| Bureau of Reclamation[a] | 0 | 4 | 1 | 7 | 6 | 0 | 0 | 0 | 0 |
| Water Resource[b] | 0 | 0 | 0 | 14 | 0 | 0 | 0 | 0 | 0 |
| Interstate[c] | 0 | 3 | 0 | 18 | 1 | 1 | 1 | 0 | 0 |
| Park Service[d] | 0 | 0 | 0 | 4 | 0 | 5 | 1 | 2 | 0 |
| Forest Service[e] | 1 | 0 | 0 | 24 | 0 | 11 | 0 | 0 | 0 |
| Kansas[f] | 0 | 2 | 0 | 9 | 1 | 1 | 4 | 0 | 0 |
| Florida[g] | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| Kentucky[h] | 0 | 0 | 0 | 21 | 0 | 0 | 1 | 0 | 0 |
| Tennessee[i] | 0 | 0 | 0 | 12 | 0 | 0 | 0 | 0 | 0 |
| Georgia[j] | 0 | 0 | 0 | 10 | 0 | 0 | 4 | 0 | 3 |
| Wyoming[k] | 0 | 0 | 0 | 4 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 1 | 9 | 1 | 125 | 8 | 18 | 11 | 2 | 3 |

*See following page for references.

[a] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems at Bureau of Reclamation Developments*, EPA-430/9-73-004, June 1973.

[b] U.S. Environmental Protection Agency, Office of Water Programs, *Sanitary Survey Of Drinking Water Systems on Federal Water Resource Developments, A Pilot Study*, August 1971.

[c] U.S. Environmental Protection Agency, Water Supply Division, *Drinking Water Systems On and Along the National System of Interstate and Defense Highways, A Pilot Study*, 1972.

[d] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems in the National Park Service System*, EPA-520/9-74-016, December 1974.

[e] U.S. Environmental Protection Agency, Water Supply Division, *A Pilot Study of Drinking Water Systems in the U.S. Forest Service System*, November 1974.

[f] U.S. Environmental Protection Agency, Region VII, Water Supply Program, *Evaluation of the Kansas Water Supply Program*, 1972.

[g] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, *Evaluation of the Florida Water Supply Program*, 1973.

[h] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, *Evaluation of the Kentucky Water Supply Program*, May 1972.

[i] U.S. Environmental Protection Agency, Region IV, Bureau of Water Hygiene, *Evaluation of the Tennessee Water Supply Program*, January 1971.

[j] U.S. Environmental Protection Agency, Region IV, Water Supply Branch, *Evaluation of the Georgia Water Supply Program*, July 1973.

[k] U.S. Environmental Protection Agency, Region VIII, Water Supply Branch, *Evaluation of the Wyoming Water Supply Program*, December 1972.

TABLE 4-21

## SPECIAL MONITORING COSTS OF COLIFORM VIOLATIONS (NON-COMMUNITY SYSTEMS)

| | |
|---|---|
| Number of tests required per month for system in violation | 7-30 |
| Estimated cost per test | \$5-\$10 |
| Monthly cost per system | \$35-\$300 |
| Percent of systems in violation survey (125 of 729) | 17.1% |
| Resultant number of systems in violation, nationwide | 34,293 |
| Total cost, nationwide[a] (\$ million) | 1.2-10.3 |

[a] Assumes that once a violation is found in the system, treatment will commence and no further violations will occur in the system after treatment commences.

## TABLE 4-22

## SPECIAL MONITORING COSTS FOR CHEMICAL VIOLATIONS (NON-COMMUNITY SYSTEMS)

| CONTAMINANT | PERCENT OF VIOLATIONS[a] | NUMBER OF TESTS REQUIRED[b] (1 Year) | COST PER TEST ($) | TOTAL COST ANNUALLY 200,000 SYSTEMS ($ million) |
|---|---|---|---|---|
| Arsenic | 0 | 8-52 | 7.7-18.5 | 0 |
| Barium | 0 | 8-52 | 7.7-18.5 | 0 |
| Cadmium | 0.96 | 8-52 | 7.7-18.5 | 0.1-1.8 |
| Chromium | 0.96 | 8-52 | 5.6-13.5 | 0-1.3 |
| Cyanide | 0 | 8-52 | 7.7-18.5 | 0 |
| Lead | 5.29 | 8-52 | 5.6-13.5 | 0.5-7.4 |
| Mercury | 2.68 | 8-52 | 11.6-28.0 | 0.5-7.8 |
| Nitrate | 2.94 | 8-52 | 5.6-13.5 | 0.3-4.1 |
| Selenium | 0 | 8-52 | 7.7-18.5 | 0 |
| Silver | 0.96 | 8-52 | 5.6-13.5 | 0.1-1.8 |
| Fluoride | 4.48 | 8-52 | 5.6-13.5 | 0.4-6.3 |
| CCE[d] | 9.80 | 8-52 | 45-70 | 0.3-3.6[e] |
| Chlorinated Hydrocarbons (7 compounds) | c | 8-52 | | 0 |
| Chlorophenoxys (2 compounds) | c | 8-52 | | 0 |
| TOTAL NATIONAL COST FOR 200,000 SYSTEMS, ONE YEAR ($ million) | | | | 2.2-34.1 |

[a] Based on 208 system sample.

[b] Assuming no closing of system.

[c] No data.

[d] Carbon chloroform extract.

[e] Assume only 5 percent surface-water systems.

## 4.6 Costs Incurred by Non-Community Systems When Contaminant Level is 75 Percent or More of Maximum Contaminant Level

The costs incurred by non-community systems in monitoring water where the contaminant level is between 75 and 100 percent of the maximum are shown in Table 4-23. When compared to all other monitoring functions, the costs incurred in this monitoring activity are minor, with mercury, fluoride and lead monitoring accounting for approximately 70 percent of the total costs.

## 4.7 Total Monitoring Costs

The costs of monitoring the 200,000 public non-community systems would account for 70 percent of the total monitoring costs of from $72 million to $151 million for the first year; routine monitoring of the 40,000 community systems would account for the remaining 30 percent (see Table 4-24). Bacteriological monitoring would account for 69 percent of the routine monitoring costs for community systems. In subsequent years, as violations are corrected, the total monitoring costs would decline. However, the 200,000 non-community systems would continue to bear the larger proportion of the costs.

## 4.8 Water Quality Data

It is essential that the underlying data and assumptions be explored before developing treatment costs. This section relates the characteristics of existing water quality data bases with the characteristics of the total national supply system. In this study, the EPA projection of 40,000 community water supply systems is assumed to be valid and the ongoing EPA inventory of community systems is taken to be representative of the population of supply systems in the country. Since this is the case, it is possible to compare the populations of other surveys against this base.

For every organic and inorganic contaminant, except mercury, ERCO used the water quality data developed in the 1969 CWSS study to evaluate the impact of implementing the Proposed Interim Primary Drinking Water Regulations. However, it was necessary to supplement the CWSS study with information from the EPA Interstate Carrier Study and the 10 EPA-State evaluation studies to obtain data on mercury violations.

## TABLE 4-23

## SPECIAL MONITORING REQUIRED WHEN CHEMICAL CONTAMINANT LEVELS ARE BETWEEN 75 AND 100 PERCENT OF MAXIMUM LEVELS (NON-COMMUNITY SYSTEMS)

| CONTAMINANT | NEAR VIOLATIONS / SYSTEMS SAMPLED | PERCENT OF VIOLATIONS | NUMBER OF TESTS REQUIRED (1 Year) | COST PER TEST ($) | TOTAL COST ANNUALLY 200,000 SYSTEMS ($ million) |
|---|---|---|---|---|---|
| Arsenic | 0 | 0 | 12 | 7.7-18.5 | 0 |
| Barium | 0 | 0 | 12 | 7.7-18.5 | 0 |
| Cadmium | 1/208 | 0.48 | 12 | 7.7-18.5 | 0.1-0.2 |
| Chromium | 1/208 | 0.48 | 12 | 5.6-13.5 | 0-0.1 |
| Cyanide | 0 | 0 | 12 | 7.7-18.5 | 0 |
| Lead | 11/208 | 5.29 | 12 | 5.6-13.5 | 0.1-1.7 |
| Mercury | 10/149 | 6.71 | 12 | 11.6-28.0 | 1.9-4.5 |
| Nitrate | 0/170 | 0 | 12 | 5.6-13.5 | 0 |
| Selenium | 3/169 | 1.78 | 12 | 7.7-18.5 | 0.3-0.8 |
| Silver | 0/208 | 0 | 12 | 5.6-13.5 | 0 |
| Fluoride | 8/134 | 5.97 | 12 | 5.6-13.5 | 0.8-1.9 |
| CCE[b] | 3/51 | 5.88 | 12 | 45-70 | 0.3-0.5 |
| Chlorinated Hydrocarbons (7 compounds) | a |  | 12 |  | 0 |
| Chlorophenoxys (2 compounds) | a |  | 12 |  | 0 |
| TOTAL NATIONAL COST FOR 200,000 SYSTEMS, ONE YEAR ($ million) |  |  |  |  | 4.1-9.7 |

[a] No data.

[b] Carbon chloroform extract. This number is inflated due to large number of surface systems.

TABLE 4-24

## TOTAL MONITORING COSTS MANDATED BY THE PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

| | FIRST YEAR ($ million) | SECOND YEAR ($ million) |
|---|---|---|
| Costs of Routine Monitoring for the 40,000 Community Systems | 22.2-42.8 | 22.2-42.8 |
| Monitoring Costs for Coliform Violations for 40,000 Community Systems | 0.3-3.2 | 0.3-3.2 |
| Monitoring Costs for Chemical Violations[a] for 40,000 Community Systems | 0.2-1.5 | 0.1-1.5 |
| Monitoring Costs When Between 75 and 100 Percent[a] of Maximum for 40,000 Community Systems | 0.6-1.4 | 0.6-1.3 |
| Routine Monitoring Costs for 200,000 Public Systems | 47.1-92.0 | 47.1-92.0 |
| Monitoring Costs for Coliform Violations[b] for 200,000 Community Systems | 0.3-2.1 | 0.3-2.1 |
| Monitoring Costs for Chemical Violations[b] for 200,000 Public Systems | 0.5-6.8 | 0.5-6.8 |
| Monitoring Costs When Between 75 and 100 Percent[b] of Maximum for 200,000 Public Systems | 0.8-1.9 | 0.8-1.9 |
| TOTAL | 72.0-151.7 | 71.9-151.6 |
| Present Coliform Monitoring Costs for 40,000 Community Systems | (-)7.3-14.4 | (-)7.3-14.4 |
| Present Coliform Monitoring Costs for 200,000 Public Systems | (-)1.2-2.4 | (-)1.2-2.4 |
| Additional Costs Mandated by Proposed Regulations | 63.5-134.9 | 63.4-134.8 |

[a] Assumes violations will be found during first two years of sampling.

[b] Assumes violations will be found during first five years of sampling.

Table 4-25 gives a summary of the water quality data presently available on community water supply systems. Since all of these water samples were analyzed using the same methodology, the results of each study should be comparable. If multiple samples were analyzed, the results were averaged to determine if the system was in violation.

There are certain inherent problems in the analyses for the contaminants shown in Table 4-25 which affect their interpretation. Barium was not analyzed if the sulfate concentration was greater than 2 mg/l, which accounts for the smaller number of barium analyses in all three studies. However, if sulfate is found to be present in this concentration in a water supply it is highly unlikely that barium will be present in a soluble form. It is, therefore, reasonable to use a value of 0.1 percent of systems in violation rather than the 2.3 percent which was based on only 43 samples, since 2.2 percent of the samples have sulfate in the water in sufficient quantity to precipitate out the barium.

Because lead is usually found in the distribution system rather than in the raw water source, it is essential that multiple testing in both source and distribution systems be done for lead contamination. This was not always done in the CWSS study.

Nitrate is mainly a groundwater problem. This is apparent in comparing the percentage of systems exceeding the maximum contaminant level in the CWSS study and the results of the interstate carrier water study in Table 4-25. Table 4-26 shows that 75.2 percent of the CWSS systems used groundwater sources while only 29.9 percent of the interstate carrier supplies used groundwater. Conversely, CCE organics, which are found mainly in surface systems, occur in higher proportions in the interstate carrier study than they are in the CWSS study.

Because of sampling requirements, the data on turbidity in the CWSS study are invalid. To be valid, turbidity sampling should be done in situ. However, in the CWSS study the samples were transported to the laboratories, and several days passed between sampling and analysis. In addition, since variations in turbidity can be expected on seasonal as well as on a diurnal basis, it is assumed for the purposes of these studies that all systems which use surface-water as a source will need to provide some form of clarification if none is presently being used.

## TABLE 4-25

## SUMMARY OF WATER QUALITY DATA AVAILABLE FOR COMMUNITY WATER SYSTEMS

| Contaminant | 1969 CWSS Study<br># of Surface Systems Analyzed | % of Surface Systems Tested in Violation | # of Groundwater Systems Analyzed | % of Groundwater Systems Tested in Violation | 1975 EPA Interstate Carrier Study<br># of Systems Analyzed | % of Systems in Violation | 10 EPA State Studies<br># of Systems Analyzed | % of Systems in Violation |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 228 | 0 | 710 | 0.42 | 544 | 0 | 252 | 0 |
| Barium[a] | 4 | 0 | 37 | 2.7 | 502 | 0 | 147 | 0.7 |
| Cadmium | 233 | 0 | 714 | 0.56 | 587 | 0 | 294 | 0.7 |
| Chromium | 233 | 0 | 714 | 0.42 | 596 | 0 | 294 | 0.5 |
| Cyanide | 228 | 0 | 710 | 0 | 189 | 0 | 164 | 0 |
| Lead | 233 | 0.43 | 714 | 2.10 | 591 | 0.3 | 295 | 1.9 |
| Mercury | - | - | - | - | 474 | 2.7 | 289 | 1.9 |
| Nitrate | 228 | 0 | 710 | 3.1 | 640 | 0 | 249 | 0.4 |
| Selenium | 227 | 0.44 | 707 | 1.13 |  | 0.24 | 250 | 2.1 |
| Silver | 233 | 0 | 714 | 0 | 483 | 0 | 294 | 0 |
| Fluoride | 233 | 0 | 714 | 5.0 |  |  | 189 | 6.3 |
| CCE-Organic |  | 3.42[a] |  |  |  |  | 107 | 5.6 |

[a] Barium was not analyzed in 677 additional groundwater systems since they had $\geq 2$mg/1 $SO_4^=$ making the presence of soluble Ba unlikely. Therefore, the cost calculations were based on 0.14 percent groundwater violations.

TABLE 4-26

## PERCENT OF COMMUNITY WATER SYSTEMS WHICH UTILIZE EACH OF FOUR SOURCES OF WATER FOR FIVE STUDIES

| SOURCE OF WATER | EPA COMMUNITY INVENTORY | 1969 CWSS | EPA INTERSTATE CARRIER | 10 EPA-STATE STUDIES | 1970 AWWA |
|---|---|---|---|---|---|
| Ground[a] | 78.2 | 75.2 | 29.9 | 60.5 | 40.4 |
| Surface[b] | 11.5 | 21.6 | 48.3 | 32.6 | 34.7 |
| Mixed[c] | 3.4 | 3.2 | 15.6 | 4.3 | 14.9 |
| Purchased[d] | 6.9 |  | 6.2 | 2.5 | 10.0 |
| TOTAL | 100.0 | 100.0 | 100.0 | 99.9 | 100.0 |

[a] Includes ground and (ground and purchased).

[b] Includes surface and (surface and purchased).

[c] Includes ground and surface and (ground and surface and purchased).

[d] Includes purchased only.

Coliform measurements are also a problem due to rapid variations in the number of organisms found. The Proposed Interim Primary Drinking Water Regulations state that numbers of violations averaged on a monthly and yearly basis should be used to determine if a system is in violation. This procedure was not followed in the three studies shown in Table 4-25. However, historical data indicate that approximately 27 percent of the systems now in operation will need to install some form of disinfection equipment in the future.

Since no analysis for mercury was made in the 1969 CWSS study, it was necessary to utilize the values found in the chemical analysis of the interstate carrier water supply systems and the 10 state evaluations to estimate the percentage of systems which would exceed the maximum level of this contaminant. A value of 2.7 percent was chosen by dividing the total number of samples analyzed in the interstate carrier and state evaluations by the number of samples which exceeded the maximum contaminant levels.

## 4.9 Expansion Factors

Since the CWSS data base for which the water quality data exists represents a different population (Table 4-27) by source of water and population served than does the EPA inventory (Table 4-28), it is necessary to apply expansion factors in order to project national treatment costs from this small sample.

The national treatment costs were determined by multiplying the percent of MCL exceeders (categorized by source of water for each contaminant) by the number of systems in each of the nine size categories. The number of plants found in this manner was then multiplied by the cost of treating the mean-sized plant in each size category.

## 4.10 Treatment Costs Incurred by Community Water Supply Systems

The costs incurred by a community in removing any contaminant are site-specific and are dependent on many exogenous factors, such as treatment facilities present, age of system, availability of alternate sources of water, and many other interrelated problems. A theoretical discussion of the chemistry involved in contaminant removal can be found in

TABLE 4-27

## BREAKDOWN OF 1969 CWSS STUDY BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SOURCE OF WATER |  |  |  |
|---|---|---|---|---|
|  | GROUND | SURFACE | MIXED | TOTAL |
| 25-99 | 10.7 | 1.2 | 0.2 | 12.1 |
| 100-499 | 26.9 | 3.8 | 0.4 | 31.1 |
| 500-999 | 8.0 | 2.8 | 0.4 | 11.2 |
| 1,000-2,499 | 8.9 | 4.8 | 0.5 | 14.2 |
| 2,500-4,999 | 5.7 | 2.4 | 0.6 | 8.7 |
| 5,000-9,999 | 6.2 | 2.2 | 0.2 | 8.6 |
| 10,000-99,999 | 7.8 | 3.1 | 0.6 | 11.5 |
| 100,000-999,999 | 1.0 | 1.2 | 0.3 | 2.5 |
| > 1,000,000 | 0[a] | 0.1 | 0 | 0.1 |
| TOTAL | 75.2 | 21.6 | 3.2 | 100.0 |

[a] Zero (0) means less than 0.1 percent.

TABLE 4-28

## BREAKDOWN OF EPA INVENTORY BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SOURCE OF WATER | | | | |
|---|---|---|---|---|---|
| | GROUND | SURFACE | MIXED | PURCHASED | TOTAL |
| 25-99 | 15.9 | 0.7 | 0 | 0.8 | 17.4 |
| 100-499 | 32.4 | 2.4 | 0.5 | 2.5 | 37.8 |
| 500-999 | 10.7 | 1.4 | 0.4 | 1.1 | 13.6 |
| 1,000-2,499 | 9.2 | 2.1 | 0.8 | 0.8 | 12.9 |
| 2,500-4,999 | 4.0 | 1.6 | 0.5 | 0.5 | 6.6 |
| 5,000-9,999 | 2.7 | 1.1 | 0.4 | 0.4 | 4.6 |
| 10,000-99,999 | 3.1 | 1.9 | 0.7 | 0.8 | 6.5 |
| 100,000-999,999 | 0.2 | 0.3 | 0.1 | 0 | 0.6 |
| >1,000,000 | 0[a] | 0 | 0 | 0 | 0 |
| TOTAL | 78.2 | 11.5 | 3.4 | 6.9 | 100.0 |

[a] Zero (0) means less than 0.1 percent.

Appendices E and F. Recognizing that each system is a separate entity, ERCO used the following methodology to develop national cost estimates for the treatment necessitated by the drinking water regulations from the data base of 969 plants studied in the 1969 CWSS study.

Those systems having problems with a particular contaminant are assigned capital and O&M costs for correcting the violation. Lead treatment costs are determined using pH control as the treatment process; ion exchange is the treatment process chosen to treat for Cd, Cr, $NO_3$, Se, Hg, and Ba. Granulated activated carbon is chosen as the treatment for CCE; activated alumina adsorption is chosen to remove excess fluoride and arsenic. (All cost functions utilized in forming capital and O&M costs can be found in Appendix G.)

A cost estimate is made to determine the capital and annual O&M costs to clarify those water systems in the EPA inventory of 40,000 systems which have surface-water supplies and do not clarify. The annual and capital costs are determined by assuming that direct filtration will be used to clarify those systems in which clarification is necessary.

In developing capital and O&M costs for disinfection, it was assumed that 27.5 percent of the systems which do not presently chlorinate will need to install chlorination equipment to meet the coliform regulation.

If a system had an inorganic violation in the CWSS study, but nonetheless had the correct remedial treatment process, the violation was attributed to system malfunction and it was considered unnecessary to calculate additional capital expenses.

The cost descriptions used are divided into two main categories. The first category is that of cost functions and estimates for water supply systems that supply more than 1,000 $m^3$/day (264,000 gpd). The second category describes the corresponding costs for small systems. There is a need for such a distinction because the costs developed for large supply systems are not valid for systems of smaller capacity. Consequently, different sets of functions are devised for the following processes: (1) clarification (consisting of direct filtration), (2) chlorination, (3) activated carbon, (4) ion exchange, (5) pH control, and (6) activated alumina.

The assumptions used in developing costs are:

1. The quantity of water production is estimated using the appropriate production figures for each population category (Table 4-2);
2. Electricity costs 3 cents per kilowatt-hour;
3. Land costs $202 per hectare;
4. Capital costs include expenses for equipment purchase, installation, construction, design, engineering study, land, site development and construction overhead. Operating and maintenance costs include labor, supplies, materials, chemicals, electric utility and general maintenance;
5. The interest rate is 7 percent;[1]
6. A 15-year payoff period is assumed.[2]

The cost functions for large water supply systems were generated primarily from the results of the report by D. Volkert & Associates.[3] These functions, which have been compared favorably with another report,[4] are summarized in Appendix G. It should be noted that the cost estimates are for individual processes and that cascading them in series may lead to lower costs. Moreover, these functions are valid only for plant capacities from 1,000 $m^3$/day (264,000 gpd) to 300,000 $m^3$/day (79.2 mgd). Unless specified, these cost estimates are in terms of 1975 dollars.

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[1] Interest rates are quite variable and show considerable fluctuation. Seven percent was the average rate for medium-risk utilities at the time of writing.

[2] This payoff period is considered to be shorter than average for the industry and would cause the results to be on the conservative side.

[3] David Volkert & Associates, Monograph of the Effectiveness and Cost of Water Treatment Processes for Removal of Specific Contaminants, Vol. 1, Technical Manual (Bethesda, Maryland: David Volkert & Associates, 1974).

[4] I.C. Watson, Resource Studies Group, Control Systems Research Inc., Study of the Feasibility of Desalting Municipal Water Supplies in Montana. Manual for Calculation of Conventional Water Treatment Costs, Supplement to Final Report (Arlington, Virginia: CSR Inc., 1972). Control Systems Research Inc. is now known as KAPPA Systems Inc., Arlington, Virginia.

Cost information for systems producing under 1,000 $m^3$/day was obtained through (1) personal conversation with several water treatment equipment manufacturers and suppliers, and (2) a study of conventional water supply costs conducted by Control Systems Research, Inc. for the Office of Saline Water, U.S. Department of the Interior.[1]

The approach used when cost information was requested from vendors included the following two steps. First, each manufacturer or supplier was queried as to the exact nature of his business. This allowed the cost data obtained to be qualified in terms of actual type of equipment and services supplied for a stated price. The various business functions of the vendors contacted included suppliers of $40 cartridge filter products for home use, manufacturers of treatment unit "packages" for commercial/industrial use, suppliers of complete clarification systems for small municipal systems and/or industrial use, and suppliers of treatment systems designed to handle site-specific problems.

Secondly, each vendor was asked to provide general cost information (capital, installation, operation/maintenance) for equipment customarily used in water treatment application within the flow rate range of interest. It is acknowledged that facilities and equipment provided in a given application are determined from several factors including: (1) raw water quality, (2) desired product water quality, (3) flow rate, (4) existing facilities, (5) systems and equipment flexibility, (6) operation and maintenance needs of equipment, and other site-specific characteristics.

Since site-specific factors are not easily quantified on a general basis, vendors were asked for a general indication of costs. Responses were therefore based on either general equipment catalogue costs or on actual vendor experience in providing facilities for small systems.

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[1] I.C. Watson, Resource Studies Group, CSR Inc., Manual for Calculation of Conventional Water Treatment Costs (Washington, D.C.: Office of Saline Water, U.S. Department of the Interior, March 1972).

The information received from vendors was supplemented with cost data contained in the aforementioned CSR study, which is also based largely on equipment cost information provided by vendors. The CSR report was prepared with an emphasis on developing cost curves for systems used in municipal applications and was designed to provide a means for estimating the costs of conventional treatment systems for individual unit operations. Cost functions derived from CSR data reflect 1972 prices and are therefore multiplied by the appropriate factor in order to present results in 1975 dollars. A 7 percent discount rate was assumed.

It should be pointed out here that the cost curves for small and large systems will not produce a continuous function. The main reason for this is that each set of curves was developed independently and perhaps under differing assumptions. The cost differences that occur at the small and large system breakpoint do not materially affect the overall cost estimates. In any event, it was not within the scope of this project to develop a single continuous function for all system sizes covered by the Act.

However, because of the tremendous range in system size, from 25 persons to over 1,000,000 persons, there are several reasons why it may be difficult to develop a continuous function for all systems:

1. Small systems can employ package plants;
2. Small systems generally do not require full-time maintenance;
3. Small system treatment package plants may not require housing facilities.

## 4.11 National Treatment Costs

Table 4-29 shows the cost of treatment by process for the average plant in each of the nine population categories. The following assumptions were implicit in using these costs to make national treatment cost projections:

1. A system will treat its present supply rather than develop an alternative supply;
2. There are no retrofit and cascading benefits when new treatment processes are added;

## TABLE 4-29

## CAPITAL TREATMENT COSTS FOR NINE POPULATION SERVED GROUPS[a]

| POPULATION SERVED | DISINFECTION | CLARIFICATION | ION EXCHANGE | pH CONTROL | ACTIVATED ALUMINA | ACTIVATED CARBON |
|---|---|---|---|---|---|---|
| 25-99 | 690 | 21,000 | 41,000 | 690 | 2,600 | 1,500 |
| 100-499 | 1,200 | 30,000 | 68,000 | 1,200 | 6,100 | 4,300 |
| 500-999 | 1,800 | 41,000 | 100,000 | 1,800 | 12,000 | 10,000 |
| 1,000-2,499 | 2,500 | 52,000 | 140,000 | 2,500 | 22,000 | 21,000 |
| 2,500-4,999 | 7,500 | 150,000 | 470,000 | 7,500 | 37,000 | 64,000 |
| 5,000-9,999 | 12,000 | 270,000 | 810,000 | 12,000 | 60,000 | 120,000 |
| 10,000-99,999 | 30,000 | 640,000 | 2,000,000 | 30,000 | 130,000 | 330,000 |
| 100,000-999,999 | 210,000 | 3,400,000 | 11,000,000 | 210,000 | 620,000 | 2,300,000 |
| >1,000,000 | 2,300,000 | 22,000,000 | 67,000,000 | 2,300,000 | 3,300,000 | 21,000,000 |

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[a] Costs were determined for average production and average size plant in each group based on EPA Community Inventory as of July 15, 1975 (Table 4-2).

3. Advanced treatment is necessary to remove all heavy metals. In many instances, however, filtration may remove enough of the contaminants so that the water may meet the standards. Alternatively, some systems may "blend" well water free of $NO_3$ with water which contains $NO_3$ so that the $NO_3$ will fall below the maximum contaminant level;

4. The inorganic violations found in this 1969 study are truly representative of the national water supply systems;

5. The information on mercury violations found in the chemical analysis of the interstate carrier water systems is representative of the country's water supply systems;

6. Chlorination units will be installed in 27.5 percent of the systems which do not presently disinfect their water supplies;

7. All surface water systems will install clarification units if they are not presently in use;

8. The mean-sized plant in each of the nine population ranges was used as a model plant to develop costs.

The national treatment costs for each contaminant and nine population-served categories are shown in Tables 4-30 to 4-40. The capital costs to treat for mercury and nitrate contaminants and turbidity account for almost 79 percent of the total costs, with O&M costs for clarification accounting for 69 percent of the total O&M costs (Table 4-41).

## 4.12 Treatment Costs for Public Non-Community Systems

With only extremely limited and questionable data available on public non-community water systems, it is almost impossible to make accurate predictions about the treatment techniques which would be required. Unlike community systems, it is quite possible that these systems would choose to stop supplying water rather than install any treatment process. However, in this analysis it will be assumed that no systems

TABLE 4-30

CAPITAL AND O&M COSTS[a] OF CHLORINATION AND CLARIFICATION UNIT PROCESSES BY POPULATION SIZE CATEGORY

| | CHLORINATION | | | | CLARIFICATION | | | |
|---|---|---|---|---|---|---|---|---|
| | | | PROCESS COSTS ($/Thousand) | | | | PROCESS COSTS ($/Thousand) | |
| POPULATION SIZE CATEGORY | NUMBER OF PLANTS | POPULATION AFFECTED | CAPITAL | O & M | NUMBER OF PLANTS | POPULATION AFFECTED | CAPITAL | O & M |
| 25-99 | 1,526 | 95,674 | 1,052 | 106 | 252 | 13,436 | 5,292 | 476 |
| 100-499 | 2,410 | 646,061 | 2,692 | 457 | 653 | 174,669 | 19,590 | 1,436 |
| 500-999 | 607 | 460,477 | 1,092 | 267 | 293 | 205,200 | 12,013 | 732 |
| 1,000-2,499 | 488 | 785,073 | 1,220 | 414 | 378 | 581,421 | 19,656 | 1,020 |
| 2,500-4,999 | 211 | 770,559 | 1,562 | 443 | 215 | 735,165 | 32,250 | 7,310 |
| 5,000-9,999 | 133 | 972,849 | 1,596 | 611 | 111 | 746,412 | 29,970 | 7,992 |
| 10,000-99,999 | 170 | 4,545,998 | 5,100 | 2,720 | 195 | 4,759,166 | 124,600 | 46,600 |
| 100,000-999,999 | 12 | 2,663,860 | 2,520 | 2,160 | 27 | 6,675,097 | 91,600 | 64,600 |
| >1,000,000 | 0 | 0 | 0 | 0 | 2 | 5,010,761 | 44,000 | 56,000 |
| TOTAL | 5,557 | 11,140,771 | 17,054 | 7,178 | 2,126 | 19,103,371 | 379,371 | 188,568 |

[a] Clarification includes direct filtration only.

## TABLE 4-31

### BREAKDOWN OF TREATMENT[a] COSTS FOR MERCURY (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SURFACE WATER CAPITAL | SURFACE WATER O & M | GROUND WATER CAPITAL | GROUND WATER O & M | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|---|---|
| 25-99 | 287,000 | 20,300 | 5,535,000 | 391,500 | 8,372 | 142 |
| 100-499 | 1,428,000 | 100,800 | 18,632,000 | 1,315,200 | 73,253 | 295 |
| 500-999 | 1,300,000 | 93,600 | 9,100,000 | 655,200 | 71,784 | 104 |
| 1,000-2,499 | 2,660,000 | 188,100 | 10,920,000 | 772,200 | 145,027 | 97 |
| 2,500-4,999 | 6,580,000 | 658,000 | 15,980,000 | 1,598,000 | 161,340 | 48 |
| 5,000-9,999 | 8,910,000 | 847,000 | 18,630,000 | 1,771,000 | 224,121 | 34 |
| 10,000-99,999 | 34,000,000 | 2,890,000 | 54,000,000 | 4,590,000 | 990,328 | 44 |
| 100,000-999,999 | 33,000,000 | 2,820,000 | 22,000,000 | 1,880,000 | 846,174 | 5 |
| >1,000,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 88,165,000 | 7,617,800 | 154,797,000 | 12,973,100 | 2,520,399 | 769 |

[a] The number of plants affected was calculated by multiplying the 2.11 percent groundwater and 2.20 percent surface-water of mercury MCL exceeders in the EPA Interstate Carrier Study by the total number of groundwater and surface-water systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE 4-32

## BREAKDOWN OF TREATMENT[a] COSTS FOR CHROMIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER |  | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
|  | CAPITAL | O & M |  |  |
| 25-99 | 1,107,000 | 78,300 | 1,601 | 27 |
| 100-499 | 3,740,000 | 264,000 | 13,472 | 55 |
| 500-999 | 1,800,000 | 129,600 | 12,602 | 18 |
| 1,000-2,499 | 2,240,000 | 158,400 | 23,081 | 16 |
| 2,500-4,999 | 3,290,000 | 329,000 | 22,728 | 7 |
| 5,000-9,999 | 4,050,000 | 385,000 | 30,724 | 5 |
| 10,000-99,999 | 12,000,000 | 1,020,000 | 115,075 | 6 |
| 100,000-999,999 | 0 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 28,227,000 | 2,364,300 | 219,283 | 134 |

[a] The number of plants affected by calculated by multiplying the 0.42 percent of chromium MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-33

### BREAKDOWN OF TREATMENT[a] COSTS FOR BARIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER | | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| | CAPITAL | O & M | | |
| 25-99 | 369,000 | 26,100 | 533 | 9 |
| 100-499 | 1,292,000 | 91,200 | 4,490 | 19 |
| 500-999 | 600,000 | 43,200 | 4,200 | 6 |
| 1,000-2,499 | 840,000 | 59,400 | 7,693 | 6 |
| 2,500-4,999 | 1,410,000 | 141,000 | 7,576 | 3 |
| 5,000-9,999 | 1,620,000 | 154,000 | 10,241 | 2 |
| 10,000-99,999 | 4,000,000 | 340,000 | 38,358 | 2 |
| 100,000-999,999 | 0 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 10,131,000 | 854,900 | 73,091 | 47 |

[a] The number of plants affected was calculated by multiplying the 0.14 percent of barium MCL exceeders in the CWSS Study by the total number of groundwater systems in each category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-34

## BREAKDOWN OF TREATMENT[a] COSTS FOR LEAD (PH CONTROL) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SURFACE WATER<br>CAPITAL | <br>O & M | GROUND WATER<br>CAPITAL | <br>O & M | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|---|---|
| 25-99 | 1,380 | 6 | 92,460 | 428 | 8,073 | 136 |
| 100-400 | 6,000 | 60 | 326,400 | 3,264 | 68,451 | 277 |
| 500-999 | 5,400 | 114 | 162,000 | 3,420 | 64,670 | 93 |
| 1,000-2,499 | 10,000 | 360 | 195,000 | 7,020 | 121,088 | 82 |
| 2,500-4,999 | 22,500 | 660 | 255,000 | 7,480 | 122,861 | 37 |
| 5,000-9,999 | 36,000 | 1,440 | 276,000 | 11,040 | 167,258 | 26 |
| 10,000-99,999 | 120,000 | 6,800 | 810,000 | 45,900 | 655,945 | 31 |
| 100,000-999,999 | 0 | 0 | 420,000 | 38,000 | 342,278 | 2 |
| >1,000,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 201,280 | 9,440 | 2,536,860 | 116,552 | 1,550,624 | 684 |

[a] The number of plants affected was calculated by multiplying the 0.43 percent surface-water and 2.10 percent groundwater of lead MCL exceeders in the CWSS Study by the total number of surface- and groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-35

### BREAKDOWN OF TREATMENT[a] COSTS FOR ARSENIC (ACTIVATED ALUMINA) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER | | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| | CAPITAL | O & M | | |
| 25-99 | 70,200 | 5,940 | 1,601 | 27 |
| 100-499 | 335,500 | 34,650 | 13,472 | 55 |
| 500-999 | 216,000 | 27,000 | 12,602 | 18 |
| 1,000-2,499 | 352,000 | 48,000 | 23,081 | 16 |
| 2,500-4,999 | 259,000 | 77,000 | 22,728 | 7 |
| 5,000-9,999 | 300,000 | 105,000 | 30,724 | 5 |
| 10,000-99,999 | 780,000 | 402,000 | 115,075 | 6 |
| 100,000-999,999 | 0 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 2,312,700 | 699,590 | 219,283 | 134 |

[a] The number of plants affected was calculated by multiplying the 0.42 percent arsenic MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-36

## BREAKDOWN OF TREATMENT[a] COSTS FOR CCE (ACTIVATED CARBON) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SURFACE WATER | | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| | CAPITAL | O & M | | |
| 25-99 | 15,000 | 38,000 | 503 | 10 |
| 100-499 | 141,900 | 204,600 | 8,657 | 33 |
| 500-999 | 190,000 | 178,600 | 13,166 | 19 |
| 1,000-2,499 | 630,000 | 390,000 | 45,192 | 30 |
| 2,500-4,999 | 1,408,000 | 858,000 | 73,304 | 22 |
| 5,000-9,999 | 2,040,000 | 765,000 | 108,456 | 17 |
| 10,000-99,999 | 8,910,000 | 1,566,000 | 640,801 | 27 |
| 100,000-999,999 | 9,200,000 | 560,000 | 971,604 | 4 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 22,534,900 | 4,560,200 | 1,861,683 | 162 |

[a] The number of plants affected was calculated by multiplying the 3.42 percent of CCE MCL exceeders in the CWSS Study by the total number of community surface-water systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE 4-37

BREAKDOWN OF TREATMENT[a] COSTS FOR $NO_3$ (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER | | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| | CAPITAL | O & M | | |
| 25-99 | 8,118,000 | 574,200 | 11,823 | 198 |
| 100-499 | 27,336,000 | 1,929,600 | 99,439 | 402 |
| 500-999 | 13,300,000 | 957,600 | 93,020 | 133 |
| 1,000-2,499 | 16,100,000 | 1,138,500 | 170,360 | 115 |
| 2,500-4,999 | 23,500,000 | 2,350,000 | 167,760 | 50 |
| 5,000-9,999 | 27,540,000 | 2,618,000 | 226,774 | 34 |
| 10,000-99,999 | 78,000,000 | 6,630,000 | 849,364 | 39 |
| 100,000-999,999 | 22,000,000 | 1,880,000 | 324,933 | 2 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 215,894,000 | 18,077,900 | 1,943,473 | 973 |

[a] The number of plants affected was calculated by multiplying the 3.1 percent of $NO_3$ MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multipled by the cost of treating the mean-sized plant in each size category.

TABLE 4-38

BREAKDOWN OF TREATMENT[a] COSTS FOR SELENIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | SURFACE WATER | | GROUND WATER | | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|---|---|
| | CAPITAL | O & M | CAPITAL | O & M | | |
| 25-99 | 82,000 | 5,800 | 2,952,000 | 208,800 | 4,375 | 74 |
| 100-499 | 340,000 | 24,000 | 9,996,000 | 705,600 | 37,362 | 152 |
| 500-999 | 300,000 | 21,600 | 4,900,000 | 352,800 | 35,602 | 52 |
| 1,000-2,499 | 560,000 | 39,600 | 5,880,000 | 415,800 | 67,914 | 46 |
| 2,500-4,999 | 1,410,000 | 141,000 | 8,930,000 | 893,000 | 70,583 | 22 |
| 5,000-9,999 | 2,430,000 | 231,000 | 10,530,000 | 1,001,000 | 96,617 | 16 |
| 10,000-99,999 | 8,000,000 | 680,000 | 30,000,000 | 2,550,000 | 392,050 | 19 |
| 100,000-999,999 | 0 | 0 | 0 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 13,122,000 | 1,143,000 | 73,188,000 | 6,127,000 | 704,503 | 381 |

[a] The number of plants affected was calculated by multiplying the 1.13 percent groundwater and 0.44 percent surface-water of selenium MCL exceeders in the EPA Inventory by the total number of groundwater and surface-water systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-39

### BREAKDOWN OF TREATMENT[a] COSTS FOR CADMIUM (ION EXCHANGE) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER CAPITAL | GROUND WATER O & M | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| 25-99 | 1,476,000 | 104,400 | 2,135 | 36 |
| 100-499 | 4,964,000 | 350,400 | 17,963 | 73 |
| 500-999 | 2,400,000 | 172,800 | 16,803 | 24 |
| 1,000-2,499 | 2,940,000 | 207,900 | 30,774 | 21 |
| 2,500-4,999 | 4,230,000 | 423,000 | 30,305 | 9 |
| 5,000-9,999 | 5,670,000 | 539,000 | 40,965 | 7 |
| 10,000-99,999 | 14,000,000 | 1,190,000 | 153,433 | 7 |
| 100,000-999,999 | 0 | 0 | 0 | 0 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 35,680,000 | 2,987,500 | 292,378 | 177 |

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[a] The number of plants affected was calculated by multiplying the 0.56 percent of cadmium MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

TABLE 4-40

## BREAKDOWN OF TREATMENT[a] COSTS FOR FLUORIDE (ACTIVATED ALUMINA) BY POPULATION SERVED AND SOURCE OF WATER

| POPULATION SERVED | GROUND WATER CAPITAL | GROUND WATER O & M | POPULATION AFFECTED | PROJECTED # OF VIOLATING PLANTS |
|---|---|---|---|---|
| 25-99 | 829,400 | 70,180 | 19,069 | 319 |
| 100-499 | 3,952,800 | 408,240 | 160,386 | 648 |
| 500-999 | 2,568,000 | 321,000 | 150,032 | 214 |
| 1,000-2,499 | 4,070,000 | 555,000 | 274,775 | 185 |
| 2,500-4,999 | 2,997,000 | 891,000 | 270,581 | 81 |
| 5,000-9,999 | 3,240,000 | 1,134,000 | 365,765 | 54 |
| 10,000-99,999 | 8,190,000 | 4,221,000 | 1,369,942 | 63 |
| 100,000-999,999 | 2,480,000 | 2,480,000 | 524,086 | 4 |
| >1,000,000 | 0 | 0 | 0 | 0 |
| TOTAL | 28,327,200 | 10,080,420 | 3,134,636 | 1,568 |

[a] The number of plants affected was calculated by multiplying the 5.0 percent of fluoride MCL exceeders in the CWSS Study by the total number of groundwater systems in each size category (Table 4-2). The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

## TABLE 4-41

## NATIONAL COSTS OF TREATING CONTAMINANTS IN DRINKING WATER[a]

| PROCESS | TREATMENT TECHNIQUE | CAPITAL COSTS ($ million) | ANNUAL O&M ($ million) |
|---|---|---|---|
| Clarification | direct filtration | 379.3 | 188.6 |
| CCE | activated carbon | 22.5 | 4.6 |
| $NO_3$ | ion exchange | 215.9 | 18.1 |
| Chlorination | disinfection | 17.0 | 7.2 |
| Mercury | ion exchange | 243.0 | 20.6 |
| Selenium | ion exchange | 86.3 | 7.2 |
| Cadmium | ion exchange | 35.7 | 3.0 |
| Lead | pH control | 2.7 | 0.1 |
| Fluoride | activated alumina | 28.3 | 10.1 |
| Chromium | ion exchange | 28.2 | 2.4 |
| Barium | ion exchange | 10.1 | 0.8 |
| Arsenic | activated alumina | 2.3 | 0.7 |
| SUB-TOTAL COMMUNITY | | 1,071.3 | 263.4 |
| SUB-TOTAL NON-COMMUNITY | | 23.6 | 4.4 |
| TOTAL | | 1,094.9 | 267.8 |

[a] The number of plants affected was calculated by multiplying the percentage of violators in each contaminant category by the total number of systems in each size and source category. The number of plants was then multiplied by the cost of treating the mean-sized plant in each size category.

will choose to close rather than treat. In the non-community system studies 17.1 percent of the systems exceeded the coliform MCL; this means that approximately 34,000 systems nationwide must disinfect. It is assumed that these 34,000 systems will install feed hypochlorinators at a capital cost of $400 or a national capital cost of $13.6 million. Since the majority of these systems operate for only 3 months of the year, the O&M is assumed to be $100 per year per plant, or a national cost of $3.4 million per year.

The only other major treatment costs encountered by these non-community systems would be for the clarification of surface-water systems. A rapid sand filter can be bought for about $5,000 for a system delivering 20 gallons per minute. It is estimated that less than 1 percent of the non-community systems use surface water as a source (Appendix B, Table B-16). This means that a maximum of 2,000 systems would need clarification, or $10 million in capital investment and an annual O&M cost of $1 million. It is highly doubtful that a non-community water supply system would invest a great deal of capital in extensive treatment systems for inorganic contaminants, although certain systems might invest a few hundred dollars in a simple ion exchange column. In general, it appears that the capital and O&M costs of these non-community systems would be minimal compared to the costs of community systems.

### 4.13 Sensitivity of Treatment Costs

The following variables were used in developing the capital and O&M requirements for water treatment facilities:

1. Construction costs

2. Site development costs

3. Labor costs

4. Land costs

5. Plant capacity

Each of these variables has an input on the local cost of constructing and running a treatment facility. Table 4-42 shows the regional variations in wages and construction cost indices which were found in March of 1975, as well as the

## TABLE 4-42

## LABOR AND CONSTRUCTION INDICES BY EPA REGION

| | I | II | III | IV | V | VI | VII | VIII | IX |
|---|---|---|---|---|---|---|---|---|---|
| March 1975 CPI Index | 2,126[a] | 2,631 | 2,374[b] | 1,670[c] | 2,374 | 1,679[d] | 2,330 | 1,705 | 2,309 |
| U.S. Average | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 | 2,128 |
| Ratio of Regional CPI to U.S. Average CPI | 1.02 | 1.24 | 1.12 | 0.78 | 1.12 | 0.79 | 1.09 | 0.80 | 1.09 |
| January 1975 BLS Wages[e] | 3.96[a] | 5.00 | 4.83[b] | 3.50[c] | 5.34 | 4.72[d] | 4.48 | 4.80 | 5.01 |
| U.S. Average | 4.71 | 4.71 | 4.71 | 4.71 | 4.71 | 4.71 | 4.71 | 4.71 | 4.71 |
| Ratio of Regional BLS to U.S. Average BLS | 0.84 | 1.06 | 1.03 | 0.74 | 1.13 | 1.00 | 0.95 | 1.02 | 1.06 |
| January 1975 Handy-Whitman Index | | | | | | | | | |
| Source | 385 | 385 | 389 | 389 | 375 | 365 | 371 | 357 | 376 |
| Pumping Structure | 358 | 358 | 377 | 377 | 379 | 364 | 379 | 335 | 378 |
| Pumping Equipment | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 | 303 |
| Plant - large | 355 | 355 | 386 | 386 | 377 | 354 | 374 | 335 | 357 |
| - small | 400 | 400 | 380 | 380 | 364 | 355 | 361 | 333 | 351 |
| Distribution Pipes | 335 | 335 | 338 | 338 | 328 | 324 | 325 | 318 | 322 |
| Building Trades Labor | 405 | 405 | 421 | 421 | 417 | 387 | 416 | 409 | 411 |

[a] Based on Boston Index.

[b] Based on Cincinnati Index.

[c] Based on Atlanta Index.

[d] Based on Denver Index.

[e] For manufacturing employees.

national average. In all calculations ERCO used the national average to compute costs, but regional variations can cause a difference of at least 20 percent in costs. Local land costs vary from site to site, but since land costs comprise only a very small percentage of total construction costs, the effect of this variable is minimal.

The major cost factor is plant capacity since this factor controls the amount of construction and material needed to build a given treatment facility. Water usage may differ markedly among cities having similar populations. For example, Wheeling, West Virginia and Everett, Washington each have water systems serving approximately 65,000 people. Wheeling treats 10 mgd while Everett treats 100 mgd, with the difference in water usage explained by the presence of two pulp plants in Everett. Other factors, such as climate, local economy, urbanization, water distribution facilities, cost to consumer, availability and variability of water sources, and the kinds of commercial and industrial establishments supplied from the municipal system, all determine the quantities of water treated.[1]

The national average water production is presently 165 gallons per consumer day (0.62 $m^3$/cd), as found in the EPA water supply inventory. The production by size category varies from 99 to 197 gpcd (0.38 to 0.74 $m^3$/cd) (see Table 4-2). A study[2] of 122 private companies (Table 4-43) yields a national average consumption of 146 gpcd (0.55 $m^3$/cd). This study also indicates that smaller communities can consume considerably less water per consumer than do larger communities. Since production is the most important factor in the price sensitivity analysis, an analysis was performed using peak day demand production. The treatment costs developed for peak day demand and average daily production are shown in Table 4-44. Using peak demand production would put a realistic upper bound on expected treatment costs, since many systems might decide to build treatment capacity to meet the expected maximum demand on the systems, rather than the average daily demand. Building larger treatment plants will not cause O&M rates to go up significantly, however, since most O&M expenses are related to total gallon throughput in the system.

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[1] Water Resources Council, The Nation's Water Resources (Washington, D.C., 1968), p. 4-1-2.

[2] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities"(Washington, D.C., 1973).

TABLE 4-43

## WATER PRODUCTION PER CAPITA PER DAY FOR 122 PRIVATE WATER COMPANIES[a]

| NUMBER OF COMPANIES | AVERAGE POPULATION SERVED | GALLONS CONSUMED PER CUSTOMER PER DAY |
|---|---|---|
| 12 | 624,339 | 140 |
| 12 | 239,359 | 147 |
| 41 | 79,474 | 162 |
| 8 | 24,885 | 135 |
| 14 | 11,711 | 142 |
| 28 | 4,435 | 119 |
| 7 | 1,166 | 74 |
| TOTAL 122 | 23,672 | 146 |

[a] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities," Washington, D.C.

## TABLE 4-44

## NATIONAL COST RANGE FOR TREATMENT OF CONTAMINANTS IN DRINKING WATER

| TREATMENT TECHNOLOGY | CONTAMINANT | CAPITAL COSTS[a] ($ million) | ANNUAL O&M ($ million) |
|---|---|---|---|
| Community Systems | | | |
| Clarification | Turbidity | 379.3 - 682.9 | 188.6 |
| Chlorination | Coliform | 17.0 - 27.4 | 7.2 |
| Ion Exchange | Ba, Cr, Cd, NO, Hg, Se | 619.2 - 996.9 | 52.3 |
| Activated Alumina | As, Fluoride | 30.6 - 52.7 | 10.8 |
| pH Control | Pb | 2.7 - 4.2 | 0.1 |
| Activated Carbon | CCE | 22.5 - 35.8 | 4.6 |
| TOTAL | | 1,071.3 - 1,800.1 | 263.6 |

[a] Lower bound assumes treatment plant designed for average daily demand; upper bound assumes treatment plant designed for peak daily demand.

# CHAPTER FIVE

## CONSTRAINTS TO IMPLEMENTATION OF THE INTERIM PRIMARY DRINKING WATER REGULATIONS

### 5.0 Introduction

This chapter explores the non-economic constraints which may hinder implementation of the Proposed Interim Primary Drinking Water Regulations. The economic factors are examined in the following two chapters. An examination of these non-economic constraints on the implementation of the interim regulations reveals that potential problem areas are the availability of trained manpower and the availability of some chemicals.

Chemical shortages might occur for some coagulants, mainly alum, ferric chloride, and synthetic polymers, as well as hypochlorites and activated carbon; it is anticipated, however, that these shortages would be only short-term local problems.

It is anticipated that a shortage of state certified laboratory facilities could delay full implementation of the water quality monitoring program called for under the Proposed Interim Primary Drinking Water Regulations. However, there are many uncertified laboratories available to perform all the routine analyses required.

This chapter examines those factors which could hinder the implementation of the Proposed Interim Primary Drinking Water Regulations. Specifically, the discussion is broken down into four separate sections, as follows:

1. Chemical Constraints
2. Manpower Constraints
3. Laboratory Constraints
4. Construction Constraints

## 5.1 Chemical Constraints

The implementation of the Proposed Interim Primary Drinking Water Regulations within a reasonable time frame depends greatly on the availability of key chemicals and supplies needed in the treatment of drinking water. The increased demand for some chemicals would require an increase in production of several percent over-and-above the quantities presently being manufactured.

The demand for many of these chemicals would be further exacerbated by the concurrent demands of other Federally mandated air and water pollution control programs.

Figure 5-1 provides a general list of water treatment chemicals grouped according to treatment process. In addition, some of the more important industrial characteristics of these chemicals are tabulated in Table 5-1. Most treatment chemicals are manufactured and distributed by the chemical industry, although the machine, petroleum, and some other industries contribute to production. The most often and most widely used chemicals, such as alum, polyelectrolytes, filter media, and chlorine products, are usually manufacturer and distributed in bulk quantities.

The chemical constraint analysis is based on the following assumptions:

1. Twenty-seven percent of the systems which presently do not chlorinate will install chlorination units;

2. All surface-water systems which do not presently clarify will do so;

3. The numbers and types of systems which exceeded one or more maximum contaminant levels in the 1969 CWSS study are representative of the country's 40,000 community systems;

4. No major treatment activity will begin until March 1977 and the maximum chemical demands will not be felt until two years later.

A critical evaluation is made for those chemicals which would require an increase in production of 5 percent or more due to implementation of the Proposed Interim Primary Drinking Water Regulations. The current and anticipated supply and

| Chemicals and Supplies / Treatment Process | Coagulation | Coagulation Aid | Disinfection | Dechlorination | pH Control | Flouridation | Flouride Adjustment | Filtration | Taste and Odor Control | Mineral Oxidation (Fe and Mn) | Ion Exchange | Stabilization and Corrosion Control | Softening | Reverse Osmosis | Electrodialysis | Ultra-filtration | Aeration | Sedimentation | Micro-screening | Distillation | Heavy Metal Removal | Sulfur Species Removal | Arsenic Removal |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Aluminum Sulfate (Bauxite) | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Ferrous Sulfate | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Ferric Sulfate | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Ferric Chloride | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Aluminate | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrated Lime & Quicklime | ✓ |  |  | ✓ |  |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  |
| Aluminum Ammonium Sulfate | ✓ |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Aluminum Potassium Sulfate | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Synthetic Organic Polymers | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |
| Bentonite |  | ✓ |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Calcium Carbonate |  | ✓ |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Carbon Dioxide |  | ✓ |  |  | ✓ |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |
| Sodium Silicate |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ammonia, Anhydrous |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ammonium Hydroxide |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |
| Ammonium Sulfate |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Bromine |  |  | ✓ |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Chlorine |  |  | ✓ |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Chlorine Dioxide (Sodium Chlorite) |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |
| Chlorinated Lime |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrochlorites (Calcium, Lithium, Sodium) |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Ozone |  |  | ✓ |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Silver |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Activated Carbon |  |  |  | ✓ |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Ion Exchange Resin |  |  |  | ✓ |  |  | ✓ |  |  |  | ✓ |  | ✓ |  |  |  |  |  |  |  |  |  |  |
| Sodium Bisulfite |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Sulfite |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sulfur Dioxide |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydrochloric Acid |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Carbonate (Soda Ash) |  |  |  |  | ✓ |  |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |
| Sodium Hydroxide |  |  |  |  | ✓ |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |
| Sulfuric Acid |  |  |  |  | ✓ |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |
| Ammonium Silico-Flouride |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fluospar |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydroflouric Acid |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Hydroflussilicic Acid |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Flouride |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Silico-Flouride |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Activated Alumina |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| "Fluo-Carb" |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| "Fluorex" |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Magnesium Oxide |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Bisulfate |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Potassium Permanganate |  |  |  |  |  |  |  |  | ✓ | ✓ |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |
| Sodium Tri-polyphosphate |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Hexametaphosphate |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |
| Copper Sulfate |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Bichromate |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Sodium Chloride |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |
| EDTA (Metal Chelating Agent) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |  |
| Ferric Hydroxide |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Aluminum Hydroxide |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |
| Ion Exchange Backwash & Regenerant |  |  |  | ✓ |  |  | ✓ |  |  |  | ✓ |  | ✓ |  |  |  |  |  |  |  |  |  |  |
| Crushed Anthricate |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Fine Sand |  |  |  |  |  |  |  | ✓ |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Membranes |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ | ✓ | ✓ |  |  |  |  |  |  |  |
| Steam |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | ✓ |  |  |  |

Figure 5-1. This figure shows chemicals used to treat drinking water.

## TABLE 5-1

## CHEMICALS USED IN WATER TREATMENT

***Chemicals Used in Disinfection and Dechloridating Agents***

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Ammonium aluminum sulfate $Al_2\,SO_4(NH_4)_2\,SO_4\,24\,H_2O$ | ammonia alum, crystal alum | Bags, bbls., bulk | duriron, lead, rubber, silicon iron stoneware | lump<br>nut<br>pea<br>powdered | 64–68<br>62<br>65<br>60 | 0.3(32°F)<br>8.3(212°F) | 11($Al_2O_3$) | pH of 1 per cent sol. 3.5 |
| Ammonium sulfate $(NH_4)_2\,SO_4$ | sulfate of ammonia | 100-lb bags | ceramics, plastics, rubber; iron (dry) | white or brown crystal | 42.5 | 6.3 (68° F) | 25 ($NH_3$) | cakes in dry feed: add $CaSO_4$ for free flow |
| Anhydrous ammonia $NH_3$ | ammonia | 50-, 100-, 150-lb cylinder, in bulk tank cars and trucks | glass, iron, monel metal, nickel, steel | colorless gas | | 3.9(32°F)<br>3.1(60°F)<br>1.8(125°F) | 99–100 ($NH_3$) | |
| Aqua ammonia $NH_4OH$ | ammonia water, ammonium hydrate, ammonium hydroxide | carboys, 750-lb drums, 8,000 gal tank cars or trucks | glass, iron, monel metal, nickel, steel | colorless liquid | | complete | 29.4($NH_3$)<br>26°Be | |
| Calcium hypochlorite $Ca(OCl)_2\,4H_2O$ | "HTH" "perchloron" "pittchlor" | 5-lb cans, 100–300, 800-lb drums | glass, rubber, stoneware, wood | white granule powder tablet | 52.5 | | 70 (available $Cl_2$) | 1–3 (available $Cl_2$ solution used) |
| Chlorinated lime $CaO\,2CaOCl_2$-$3\,H_2O$ | bleaching powder, chloride of lime | 100-, 300-, 800-lb drums | glass, rubber, stoneware, wood | white powder | 48 | | 25–37 (available $Cl_2$) | deteriorates |
| Chlorine $Cl_2$ | chlorine gas, liquid chlorine | 100-, 150-lb cylinders; 1-ton tanks; 16-, 30-, 55-ton tank cars | dry-black iron, copper, steel; wet gas-glass, hard rubber, silver | liquefied gas under pressure | 91.7 | 0.07(60°F)<br>0.04(100°F) | 99.8($Cl_2$) | |
| Chlorine dioxide $ClO_2$ | chlorine dioxide | generated as used | plastics, soft rubber (avoid hard rubber) | yellow-red gas | | 0.02(30mu) | 26.3 (available $Cl_2$) | |
| Ozone $O_3$ | ozone | generated at site of application | aluminum, ceramics, iron, steel, wood | colorless gas | | | | |

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Pyro sodium sulfite | sodium metabisulfite | bags, drums, bbls. | iron, steel, wood | white crystalline powder, clean solv. | | complete in water | dry 67 $SO_2$<br>Sol 33.3 ($SO_2$) | sulfurous odor |
| Sodium chlorite $NaClO_2$ | technical sodium chlorite | 100-lb drums | metals (avoid cellulose materials) | light orange powder, flake | | | 82($NaClO_2$)<br>30 (available $Cl_2$) | generates $ClO_2$ at pH 3.0 |
| Sodium hypochlorite $NaOCl$ | sodium hypochlorite | 5-, 13-, 50-gal carboys, 1,300–2000-gal tank trucks | ceramics, glass, plastics, rubber | light yellow liquid | | | 12–15 (available $Cl_2$) | |
| Sodium sulfite $Na_2SO_3$ | sulfite | bags, drums, bbls | iron, steel, wood | white crystalline powder | | complete in water | 23($SO_2$) | sulfurous taste and odor |
| Sulfur dioxide $SO_2$ | sulfurous acid anhydride | steel cylinders, ton containers, tank cars, or trucks | aluminum, brass, Durco D-10, stainless steel 316 | colorless gas | | 20 per cent at 32°F, complete in water | 99($SO_2$) | irritating gas |

## TABLE 5-1

## CHEMICALS USED IN WATER TREATMENT (Contd.)

### *Chemicals Used in Fluoridation and Fluoride Adjustment*

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Ammonium, silico fluoride $(NH_4)_2 SiF_6$ | ammonium fluorsilicate | 100-lb and 400-lb drums | steel, iron, lead | white crystals | | 1.7(63°F) | 100 | white, free-flowing solid |
| Calcium fluoride $CaF_2$ | fluorspar | bags, drums, bbls., hopper cars, trucks | steel, iron, lead | powder | | V.Sl. sol. | 85 ($CaF_2$)<br>less than 5 ($SiO_2$) | |
| Hydro-fluosilicic acid $H_2SiF_6$ | fluosilicic acid | rubber-lined drums, truck or railroad tank cars | rubberlined steel PVC | liquid | | approx. 1.2 (63°F) | 35 (approx.) | |
| Hydrogen fluoride HF | hydrofluoric acid | steel drums, tank cars | steel | liquid | | | 70(HF) | below 60 per cent steel cannot be used |
| Sodium fluoride NaF | fluoride | bags, bbls., fiber drums, kegs | iron, lead, steel | nile blue or white powder<br>light<br>dense | <br>50<br>75 | 0.35 (most temps.) | 90–95(NaF) | pH of 4 per cent solution 6.6 |
| Sodium silicofluoride $Na_2SiF_6$ | sodium silicofluoride | bags, bbls., fiber drums | iron, lead, steel | nile blue or yellowish-white powder | 72 | 0.03(32°F)<br>0.06(72°F)<br>0.12(140°F) | 99($Na_2$)<br>($SiF_6$) | pH or 1 per cent solution 5.3 |
| Aluminum oxide $Al_2O_3$ | activated alumina | bags, drums | iron, lead, steel | powder<br>granules (up to 1½ in. in diameter) | | insoluble | 100 | |
| Bone charcoal | "Fluor-carb" | bags, drums, bulk | wood, iron, steel | granules | variable | | | black: best used in beds for persolution |
| Tricalcium phosphate | "Fluorex" | bags, drums, bulk, bbls. | iron, steel | granular technical | variable | insoluble | | also available as white powder |
| High magnesium lime | dolomitic lime | bags, bbls., bulk | wood, iron, steel | lump<br>pebble<br>ground | 50–63 | slakes slowly | 58(CaO)<br>40(Mg) | |

### *Chemicals Used in Stabilisation and Corrosion Control*

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Disodium phosphate $Na_2HPO_4 \cdot 12H_2O$ | basic sodium phosphate, DSP, secondary sodium phosphate | 125-lb kegs,<br>200-lb bags,<br>325-lb bbls. | cast iron, steel | crystal | 60–64 | 0.4(32°F)<br>6.4(86°F) | 19.19<br>5($P_2O_5$) | precipitates ca, Mg, pH of 1 per cent solution, 9.1 |
| Sodium hexa-metolphosphate $Na(PO_3)_6$ | "Calgon"glassy phosphate vitreous phosphate | 100-lb bags | hard rubber, plastics, stainless steel | crystal<br>flake<br>powder | 47 | 1–4.2 | 66($P_2O_5$ unadjusted) | pH of 0.25 per cent solution 6.0–8.3 |
| Sodium hydroxide NaOH | caustic soda, soda lye | 100–700-lb drums; bulk (trucks, tank-cars) | cast iron, rubber, steel | flake,<br>lump<br>liquid | | 2.4(32°F)<br>4.4(68°F)<br>4.8(104°F) | 98.9(NaOH)<br>74–76($NaO_2$) | solid hygroscopic pH of 1 per cent solution, 12.9 |
| Sulfuric acid $H_2SO_4$ | oil of vitriol, vitriol | bottles, carboys, drums, trucks, tank cars | concentrated iron, steel; dilute glass, lead, porcelain, rubber | solution | (60–66°) Be | complete | 60°Be<br>77.7($H_2SO_4$)<br>66°Be<br>93.2($H_2SO_4$) | approx. pH of 0.5 per cent solution, 1.2 |
| Tetrasodium pyro-phosphate $Na_4P_2O_7 \cdot 10\ H_2O$ | alkaline sodium pyrophosphate TSPP | 125-lb kegs,<br>200-lb bags,<br>300-lb bbls. | cast iron, steel | white powder | 68 | 0.6(80°F)<br>3.3(212°F) | 53($P_2O_5$) | pH of 1 per cent solution, 10.8 |
| Trisodium phosphate $Na_3PO_4 \cdot 12\ H_2O$ | normal sodium phosphate, tertiary sodium phosphate TSP | 125-lb kegs,<br>200-lb bags,<br>325-lb bbls. | cast iron, steel | crystal—<br>course<br>medium<br>standard | <br>56<br>58<br>61 | 0.1(32°F)<br>13.0(158°F) | 19($P_2O_5$) | pH of 1 per cent solution, 11.9 |

TABLE 5-1

## CHEMICALS USED IN WATER TREATMENT (Contd.)

### *Chemicals Used in Taste and Odor Control*

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Activated carbon<br>C | "Aqua Nuchor"<br>"Hydrodarco"<br>"Herite" | bags, bulk | dry iron, steel; wet rubber, silicon, iron, stainless steel | black<br>granules<br>powder | 15 | insoluble (suspension used) | | |
| Chlorine<br>$Cl_2$ | chlorine gas, liquid chlorine | 100-, 150-lb cylinders; 1-ton tanks; 16 30-55-ton tank cars | dry black iron, copper, steel; wet gas glass, hard rubber, silver | liquified gas under pressure | 91.7 | 0.07(60°F)<br>0.04(100°F) | 99.8($Cl_2$) | |
| Chlorine dioxide<br>$ClO_2$ | chlorine dioxide | generated as used | plastics, soft rubber (avoid hard rubber) | yellow-red gas | | 0.02(30 mm) | 26.3 (available $Cl_2$) | |
| Copper sulfate<br>$CuSO_4 \cdot 5\,H_2O$ | blue vitriol, blue stone | 100-lb bags, 450-lb bbls, drums | asphalt, silicon, iron, stainless steel | crystal<br>lump<br>powder | 75–90<br>73–80<br>60–64 | 1.6(32°F)<br>2.2(68°F)<br>2.6(86°F) | 99($CuSO_4$) | |
| Ozone<br>$O_3$ | ozone | generated at site of application | aluminum, ceramics, glass | colorless gas | | | | |
| Potassium permanganate<br>$KMnO_4$ | purple salt | bulk, bbls., drums | iron, steel wool | purple crystals | | infinite | 100 | danger of explosion in contact organic matters |

### *Chemicals Used in Softening Process*

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| Calcium oxide<br>CaO | burnt lime,<br>chemical lime,<br>quicklime,<br>unslaked lime | 50-lb bags,<br>100-lb bbls.<br>bulk (carloads) | asphalt, cement, iron, rubber, steel | lump<br>pebble<br>granule | | slaked to form hydrated lime | 75–99(CaO) | pH of saturated solution, on detention time temp. amount of water critical for efficient slaking |
| Sodium carbonate<br>$Na_2CO_3$ | soda ash | bags, bbls., bulk (carloads), trucks | iron, rubber, steel | white powder<br>extra light<br>light<br>dense | <br>23<br>35<br>65 | 1.5(68°F)<br>2.3(86°F) | 99.4 ($Na_2CO_3$)<br>58($Na_2O$) | hopper agitation required for dry feed of light and extra light forms pH of 1 per cent solution,11.3 |
| Sodium chloride<br>NaCl | common salt<br>salt | bags, bbls., bulk (carloads) | bronze, cement, rubber | rock<br>fine | | 2.9(32°F)<br>3.0(68°F)<br>86°F | 98(NaCl) | |
| Calcium hydroxide<br>$Ca(OH)_2$ | hydrated lime,<br>slaked lime | 50-lb bags,<br>100-lb bbls.<br>bulk (carloads)<br>bulk trucks | asphalt, cement, iron, rubber, steel | white powder<br>light<br>dense | | 0.014(68°F)<br>0.012(90°F) | 85–99 ($Ca(OH)_2$)<br>63–73(CaO) | hopper agitation required for dry feed of light form |

engineering services and construction services under a single multi-community contract at a substantial savings to each. While regional efforts to establish coordinated river basin organizations for the purposes of managing water supply quality are not presently in wide usage, such units have great theoretical adavantages and may be worth further exploration.

# TABLE 5-1

## CHEMICALS USED IN WATER TREATMENT (Contd.)

***Chemicals Used in Coagulation Process***

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| **Aluminum sulfate $Al_2(SO_4)_3$ 14 $H_2O$** | alum, filter alum<br>sulfate of alumina | 100–200-lb bags<br>300–400-lb bbls.<br>bulk (carloads)<br>tank truck<br>tank car | dry-iron, steel.<br>solution lead-lined rubber, silicon asphalt, 316 stainless steel | ivory-colored<br>powder<br>granule<br>lump<br>liquid | 38–45<br>60–63<br>62–67<br>10 (lb/g) | 4.2 (60°F) | 15–22 ($Al_2O_3$)<br>8 ($Al_2O_3$) | pH of 1 per cent solution 3.4 |
| **Ammonium aluminum sulfate $Al_2(SO_4)_3$ $(NH_4)_2$-$SO_4$-24 $H_2O$** | ammonia alum<br>crystal alum | bags, bbls. bulk | duriron lead<br>rubber silicon<br>iron stoneware | lump<br>nut<br>pea<br>powdered | 64–68<br>62<br>65<br>60 | 0.3 (32°F)<br>8.3 (212°F) | 11 ($Al_2O_3$) | pH of 1 per cent solution 3.5 |
| **Bentonite** | colloidal clay<br>volclay<br>wilkinite | 100-lb bags<br>bulk | iron, steel | powder<br>pellet<br>mixed sizes | 60 | insoluble (colloidal sol used) | | |
| **Ferric chloride $FeCl_3$ (35–45 per cent solution)** | "ferrichlor"<br>chloride of iron | 5–13-gal carboys,<br>trucks,<br>tank cars | glass, rubber, stoneware, synthetic resins | dark brown syrupy liquid | | complete | 37–47 ($FeCl_3$)<br>20–21 (Fe) | hygroscopic (store lumps and powder in tight container) no dry feed; optimum pH, 4.0–11.0 |
| **$FeCl_3$-6 $H_2O$** | crystal ferric chloride | 300-lb bbls. | | yellow-brown lump | | | 59–61 ($FeCl_3$)<br>20–21 (Fe) | |
| **$FeCl_3$** | anhydrous ferric chloride | 500-lb casks;<br>100–300, 400-lb kegs | | green-black powder | | | 98 ($FeCl_3$)<br>34 (Fe) | |
| **Ferric sulfate $Fe_2(SO_4)_3$ 9 $H_2O$** | "ferrifloc"<br>ferrisul | 100–175-lb bags<br>400–425-lb drums | ceramics, lead<br>plastic rubber<br>18-8 stainless steel | red-brown powder<br>70- or granule 72 | | soluble in 2–4 parts cold water | 90–94 (Fe) $(SO)_3$<br>25–26 (Fe) | mildly hygroscopic coagulant at pH 3.5–11.0 |
| **Ferrous sulfate $FeSO_4$ 7 $H_2O$** | copperas,<br>green vitriol | bags, bbls. bulk | asphalt, concrete<br>lead, tin, wood | green-crystal<br>granule, lump | 63–66 | | 55 ($FeSo_4$)<br>20 (Fe) | hygroscopic; cakes in storage; optimum pH 8.5–11.0 |

| Chemical Name and Formula | Common or Trade Name | Shipping Containers | Suitable Handling Materials | Available Forms | Weight *lb/cu ft* | Solubility *lb/gal* | Commercial Strength *per cent* | Characteristics |
|---|---|---|---|---|---|---|---|---|
| **Potassium aluminum sulfate $K_2SO_4$-$Al_2(SO_4)_3$ 24 $H_2O$** | potash alum | bags, lead-lined bulk (carloads) | lead, lead-lined rubber, stoneware | lump<br>granule<br>powder | 62–67<br>60–65<br>60 | 0.5 (32°F)<br>1.0 (68°F)<br>1.4 (86°F) | 10–11 ($Al_2O_3$) | low, even solubility; pH of 1 per cent solution, 3.5 |
| **Sodium aluminate $Na_2O$ $Al_2O_3$** | soda alum | 100–150-lb bags<br>250–440-lb drums, solution | iron, plastics, rubber, steel | brown powder<br>liquid (27°Be) | 50–60 | 3.0 (68°F)<br>3.3 (86°F) | 70–80 ($Na_2$) $Al_2O_4$ min.<br>32 $Na_2$ $Al_2O_4$ | hopper agitation required for dry feed |
| **Sodium silicate $Na_2O$ $SiO_2$** | water glass | drums, bulk (tank trucks, tank cars) | cast iron, rubber, steel | opaque, viscous liquid | | complete | 38–42°Be | variable ratio of $Na_2O$ to $SiO_2$; pH of 1 per cent solution, 12.3 |

demand factors for alum, ferric chloride, synthetic polymers, hypochlorites, and activated carbon are specifically examined. Table 5-2 gives a summary of the findings of the chemical constraints analysis.

Table 5-3 summarizes the number of systems which would need treatment to reduce the levels of certain contaminants below the maximum concentration permitted under the Proposed Interim Primary Drinking Water Regulations.

### 5.1.1 Coagulation

One of the most important processes conventionally utilized in the treatment of supply water is coagulation and subsequent sedimentation or filtration. Strictly speaking, engineers use the term "flocculation" to refer to the chemical agglomeration of suspended solids and colloidal materials, and the term "settling" to refer to the gravitational descent of these particles to the floor of the sedimentation basin. These concomitant processes have traditionally been important in water treatment for purposes of clarification, particularly in turbid waters. Because of the high incidence of undesirable turbidity in water supplies throughout the United States, many existing community supply treatment plants utilize this process. It is usually the first of a series of processes which also includes filtration followed by disinfection.

Coagulation is particularly important to the implementation of the Proposed Interim Primary Drinking Water Regulations in decreasing turbidity and removing contaminants. The maximum contaminant level of turbidity in drinking water is not to exceed one turbidity unit; many reservoirs, however, have turbidities in the tens of turbidity units. Coagulation can remove to some degree all of the other contaminants to which the standards are addressed; i.e., inorganics, organics, and microbiological pollutants. Research has already proven that additional coagulation has the capability of reducing inorganic contaminants to suitable levels when they exceed the regulations by a small degree. In addition, high turbidities may interfere with the disinfection process.

Because of changing technologies, prices, and market requirements, the types of coagulants used are also changing. Most experts agree that while the use of both alum and ferric salts will increase over the following decade, the volume of organic polymers used in coagulation will accelerate even more significantly. Municipal water clarification is expected to account for 25 percent of all coagulant utilization by 1980.

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## TABLE 5-2

## CONSTRAINT ANALYSIS OF KEY WATER TREATMENT CHEMICALS AND SUPPLIES[a]

| Chemical or Supply | Process | Unit Cost | Current U.S. Prod./Yr. | (1980) Added Demand from IPDWS/Yr.[c] | % Current Product'n | Added cost/yr (millions of 1974 dollars) | Availability Outlook[d] |
|---|---|---|---|---|---|---|---|
| 1. Alum | Coagulation | $85/ ton | 1,136,000 tons (1973) | ≤ 185,000 tons | 16.3% | max.$16.2 | Generally favorable, except that essentially all alum production is dependent on foreign imports of bauxite. Politically sensitive. |
| 2. Ferric Chloride | Coagulation | $100/ ton | 115,000 tons | ≤25,000 tons | ≤22% | $ 2.5 | The U.S. is self-sufficient in chloride production, but must import 50% of its iron. Both are available in more than adequate quantities. Cost is high. |
| 3. Synthetic Polymers[b] | Coagulation Coagulant Aids-Filter Aids | $1.00/ lb. |  | ≤ 5,000 tons |  | max.$10.0 | While there are a number of component monomers in short supply, this is not expected to create any significant supply problems. |
| 4. Lime | Coagulant Aid - pH Control - Calcium Hypochlorite production | $25/ ton | 250,000,000 tons | 250,000 tons | 1.0% | $6.25 | Extremely abundant in U.S. Improvements in extraction and transport techniques of limestone will be necessary to keep costs of lime low. |
| 5. Sand | Filtration (pressure and multi-media) | $1.30/ ton | 913,375,000 tons | 111,000 tons | 0.01% | $0.15 (assumes yearly replacement) | U.S. Resources are extremely abundant on the whole, although local depletions are occurring near heavily urbanized metropolitan areas. |
| 6. Anthracite | Filtration (Rapid Sand Multi-media) | $12/ ton | 7,100,000 tons | 116,700 tons | 1.65% | $1.40 (assumes yearly replacement) | While production costs may continue to rise, there will be no trouble meeting additional demands. All anthracite is found in the northeastern sector of Pennsylvania. |
| 7. Chlorine | Disinfection | 19¢/ lb. | 12,000,000 tons | 83,000 tons | 0.69% | $16.6 | Supply should be adequate. Sensitive to power industry and fluctuations in electric generation. Supply was inadequat in 1972 due to economic conditi |
| 8. Hypochlorites | Disinfection | $41/ 100 lb | 150,000 tons | 10,000 tons | 6.7% | $8.2 | Production presently at capacity demand for pools strong. Price hikes forthcoming. |
| 9. Ion Exchange Resins | Inorganic Cation Removal | $60/ $\text{ft}^3$ | styrene resins and copolymers<br>351,500 tons | 215,300 $\text{ft}^3$ initially | 1.4% | ≤$13.0 initially[a] | No problems should occur if the petroleum industry remains stabl - General inflationary trends will be reflected in costs of resins. |
|  | Nitrate Removal |  |  | 68,850 $\text{ft}^3$ initially | 0.45% | ≤$4.0 initially[a] |  |
| 10. Sulfuric Acid | Ion exchange-Regeneration | $53/ ton | 31,590,000 tons | 235,500 tons | 0.75% | $12.5 | Abundant. Periodic competition for sulfur from fertilizer industry may affect seasonal costs. |
| 11. Sodium Hydroxide | Ion Exchange - Regeneration | $12/ 100 lb | 10,680,000 tons | 75,400 tons | 0.71% | $18.1 | Tied to chlorine manufacture. Inventories are presently low. Prices will rise by late 1975. |
| 12. Activated Carbon | Organic removal | 40¢/lb | 85,000 tons | 1,676-3,353 tons | 1.97%-3.94% | $1.3-$2.7 | Reserves are abundant, and increased production to meet demand for supply water treatment should not create any serious problems. New plants may be necessary. |
| 13. Membranes R/O | Organic Removal | 25-40¢/ 1000gal. treated |  | Cellulose acetate not competitive. |  |  | Economically undesirable, althou may be used in special cases of high organic concentrations. Cellulose acetate can easily be produced to meet small demands. |
| 14. Soda Ash | pH control Heavy metal removal | $50/ ton | sodium carbonate 7,496,000 tons | 46,000 tons | 0.61% | $2.2 | Abundant. |
| 15. Activated Alumina | Defluoridation | $14/ 100 lb. | bauxite 1,812,000 tons | 9,590 $\text{ft}^3$ | 0.28% of bauxite production | $1.7 | See Alum. |

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[a] List prices as of April 18, 1975 for large lots f.o.b. New York.

[b] See text for further explanation.

[c] IPDWS = Interim Primary Drinking Water Standards.

[d] Reflects chemical supply industry impressions based on current usage trends in the water supply industry. If there are any large scale technology shifts this outlook would change.

## TABLE 5-3

## NUMBER OF COMMUNITY SYSTEMS WHICH WILL NEED TREATMENT TO MEET PROPOSED INTERIM PRIMARY DRINKING WATER REGULATIONS

| TREATMENT | | PRIMARY CONTAMINANT(S) TREATED | NUMBER OF SYSTEMS |
|---|---|---|---|
| Chlorination[a] | | Coliform | 5,557 |
| Activated Carbon[b] | | CCE | 162 |
| Clarification[c] | Direct Filtration | Turbidity | 2,126 |
| Ion Exchange[b,d] | | Ba, $NO_3$, Cd, Cr, Se, Hg | 2,481 |
| Activated Alumina[b] | | Fluoride | 1,702 |
| pH Control[b] | | Pb, As | 684 |

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[a] Assumes 27.5 percent of systems in EPA Community Water Supply Inventory without disinfection will install chlorination facilities.

[b] Based on number of systems violating one or more maximum contaminant levels in the 1969 CWSS study.

[c] Assumes all systems in EPA Community Water Supply Inventory without clarification will install clarification facilities.

[d] Includes 761 systems estimated to violate mercury standard.

Alum is presently the flocculant most widely used in the water treatment industry. It is a low-cost material and its use can be enhanced, as is discussed later, by the addition of polyelectrolytes. Alum production in 1973 was 2.27 billion pounds (1,136 million tons), approximately 26.5 percent (640 million pounds) of which was used in the treatment of supply water. Projections indicate that a maximum additional 370 million pounds would be necessary to meet the new standards, depending on the ability of the newly developed electrolyte coagulants to displace alum. Opinions from the manufacturing industry presently indicate that the future supply of alum to meet this demand should not be a problem. Bauxite is the key component of alum. Its production was 1,812,000 long tons in 1972 and it is presently viewed as a plentiful resource. Bauxite is an extremely abundant material, although the majority of reserves are located in the less industrialized countries. As such, it must be transported long distances to conversion and consumption centers, and its availability is sensitive to changes in the political climates of some areas. World reserves total about 5.8 billion tons, most of which are found in Guinea and Jamaica.

World production of bauxite has generally grown at the rate of 10 percent per year. U.S. demand for aluminum is expected to grow annually between 3.5 and 5.8 percent for non-metallic uses. While serious shortages of low-grade bauxite are not expected to develop, the United States will have to depend on foreign exports for its aluminum compounds since domestic supplies are small and difficult to mine. Alum accounts for $20.5 million of current water treatment costs, and may cost as much as an additional $16.2 million by 1980, dependent on the factors discussed above. The largest producers of filter grade alum are Allied Chemical, American Cyanamid, DuPont, Essex, Monsanto, Olin, and Stauffer.

Ferric salts, and particularly ferric chloride, are a second group of coagulants which are used in water treatment. In the past, the use of ferric chloride has been restricted in water treatment because it is corrosive to most common metals and consequently to pipes. It is expected that the advent of new pipe and storage tank materials, particularly PVC, fiber glass, and plastic- or rubber-lined pipes and tanks, will allow wider use of ferric chloride. The advantages of ferric chloride are:

1. Compared to alum, only one-half to two-thirds as much ferric chloride is required for coagulation. Although it is currently about twice the price of alum, its cost is competitive;

2. A treatment plant using ferric chloride can be operated on an optimum pH, rather than at low coagulation pH, which is corrosive. This eliminates post-coagulation lime and/or phosphate addition, and the cathodic protection necessary in alum treatment plants;

3. Ferric chloride is superior to alum in removing undesirable color from water;

4. Storage capacity and operation and maintenance allocations are reduced when ferric chloride is used instead of alum.

Preliminary estimates show that ferric chloride may account for 15 to 20 percent of the supply water coagulant market by 1980, reaching sales of between $2 million and $3 million. Total production of ferric chloride may reach as high as 280 million pounds by the same year. Chloride is produced by the reaction of metallic iron with recycled ferric chloride to produce ferrous chloride and then further reaction with chlorine gas to produce ferric chloride. It is also made by the direct chlorination of waste pickle liquor from titanium oxide manufacture. Iron supplies are presently viewed as "inexhaustible", although the United States must now import about one-half its supply. Chlorine is abundantly produced, although it can be sensitive to fluctuations in power generation. The high price of both chlorine and scrap iron may put economic stresses on the production of ferric chloride. Major producers of ferric chloride are Allied Chemical, Chem-Met, Conservation Chemical, Dow Chemical, Pennwalt, Southern California Chemical, and Steel Chemical. Supply is not expected to be a problem.

The third class of coagulants to be considered are the organic polyelectrolytes or synthetic organic polymers. Basically, these polymers are synthesized from monomeric sub-units, many of which may be toxic to the human body in certain dosages. Since all polymers carry a certain amount of residual monomer, the distribution of these chemicals must be controlled. A partial listing of some U.S. Public Health Service-approved synthetic polymers is given in Table 5-4.

## TABLE 5-4

## SYNTHETIC ORGANIC POLYMERS APPROVED FOR WATER TREATMENT[a]

| MANUFACTURER | PRODUCT | MAXIMUM CONCENTRATION RECOMMENDED BY MANUFACTURER, ppm |
|---|---|---|
| Allyn Chemical Co. | Claron | 1.5 |
| North American Mogul Products Co. | Claron #207 (identical to Claron) | 2 |
| | Mogul CO-980 (identical to Claron #207) | 1.5 |
| American Cyanamid Co. | Magnifloc 990 | 1 |
| The Burtonite Co. | Burtonite #78 | 5 |
| Dow Chemical Co. | Separan NP10 potable water grade | 1 |
| | Purifloc N17 | 1 |
| North American Mogul Products Co. | Mogul CO-983 (identical to Separan NP10 potable water grade) | 1 |
| Dearborn Chemical Co. | Aquafloc 422 (identical to Separan NP10 potable water grade) | 1 |
| Key Chemicals, Inc. | Key-Floc-W (a 4% aqueous solution of Separan NP10 potable water grade) | 25 |
| Betz Laboratories, Inc. | Poly-Floc 4D (a 4% aqueous solution of Separan NP10 potable water grade) | 25 |
| Drew Chemical Co. | Drewfloc | 1.8 alum<br>0.5:10 lime |
| Electric Chemical Co. | Ecco Suspension Catalyzer #146 | 3.5 |
| Metalene Chemical Co. | Metalene Coagulant P-6 | 5 |

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[a] The names of more recent approvals may be obtained by consulting the current waterworks literature.

Basically, polyelectrolytes may serve three different functions in supply water treatment:

1. As flocculating agents which agglomerate suspended and colloidal materials;

2. As flocculant aids when used in conjunction with inorganic coagulants for the optimum reduction of turbidity and removal of color and odor;

3. As filter aids: polyelectrolytes produce stronger floc than alum or ferric salts, and consequently allow increased flow through filters.

Some of the monomers used in the production of supply water treatment polymers are available in copious quantities, while others appear to be in short supply. A telephone survey showed that adequate supplies will be available to insure that future demands can be met.

Polymers are advantageous in that they improve performance and lower the costs in water clarification and are generally biodegradable, small in volume, easily incinerated, and effective under varied pH and temperature conditions. They appear to be cheaper on the whole than alum or ferric salts per million gallons of water treated. Upper bounds on treatment costs are estimated at $100 per million gallons, with the range of unit costs at $0.40 to $2.50 per pound of solid polymer. Dosages are on the order of 0.1 to 4.0 mg/l for clarification, as compared to 5 to 4.0 mg/l alum and 3 to 20 mg/l ferric chloride. One source has estimated that polyelectrolyte coagulants will displace 50 percent of all other flocculants by 1980, although it seems unlikely that such a drastic change will be made in such a short amount of time. Projections indicate that 10 to 20 million pounds of polymers will be utilized by the water treatment industry by 1980, at a cost of $10 to $20 million. Key producers are American Cyanamid, Dow, Hercules, Merck-Calgon, Nalco, National Starch, Ruchhold, Rohm and Haas, U.S. Filter, and Vistron.

Currently, municipalities use coagulants more than industries, and coagulants are used more for water clarification than for wastewater treatment. However, the increasing use of coagulants to treat industrial wastewater is expected to change this ratio (Table 5-5).

## TABLE 5-5

## COAGULANTS BY END MARKET[a,b]

| ITEM | | 1970 (%) | 1980 (%) |
|---|---|---|---|
| WATER CLARIFICATION | | | |
| Municipal | | 31 | 25 |
| Industrial | | 32 | 33 |
| | TOTAL | 63 | 58 |
| WASTEWATER TREATMENT | | | |
| Municipal | | 29 | 30 |
| Industrial | | 8 | 12 |
| | TOTAL | 37 | 42 |
| ALL WATER TREATMENT | | | |
| Municipal | | 60 | 55 |
| Industrial | | 40 | 45 |
| | TOTAL | 100 | 100 |

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[a] A.C. Gross, "Markets for Chemicals Grow and Grow," Environmental Science and Technology, 8(5): 415, May 1974.

[b] No consideration of Interim Primary Drinking Water Regulations implementation, and drinking water effluent guidelines in these predictions.

The predicted demand curves for coagulants are shown in Figure 5-2. These predictions were made before the primary drinking water regulations were developed and thus do not reflect an increased demand for coagulants in order to meet those standards.

In addition to an increasing demand for polymers as coagulants, it is anticipated that in the coming decade polymers will be in increasing demand for use in advanced oil recovery.

All chemical coagulant manufacturers and suppliers surveyed indicated that there would be essentially no time lag in the delivery of materials due to a sudden demand arising from the implementation of the Proposed Interim Drinking Water Regulations. However, at the time of the survey most of the major manufacturers contacted were unaware of the impact of the Proposed Interim Primary Drinking Water Regulations. It is reasonable to assume that a rapid growth of the water supply industry's demands for certain chemicals could cause spot shortages of key chemicals if no advanced warning is given to the chemical suppliers. Buying is generally based on a bidding procedure and award of sales contract. One year may pass before the material is actually sold; however, since it is over two and one-half years before a treatment system can be designed and constructed, ample time should be available for treatment plants to locate suitable chemical suppliers, provided the chemical industry is aware of the projected chemical demands.

### 5.1.2 Disinfection

Disinfection is another major treatment process whose increased use would be required by the Proposed Interim Primary Drinking Water Regulations. It is estimated that approximately 5,557 community systems would require additional disinfection, and that many of the 200,000 non-community suppliers would need biocidal treatment.

Calcium hypochlorite, sodium hypochlorite, and other inorganic chlorine compounds should continue to show a fast growth rate. They are expected to be ideal biocidal agents for non-community water supplies because they are easily and safely handled in cylinders, and pose little threat of rapid dispersal if injected suddenly. Hypochlorites also reduce capital costs. Olin Chemical, the largest manufacturer (50,000 to 60,000 tons/year), produces calcium hypochlorite under the trade name HTH. It is composed of 70 percent free

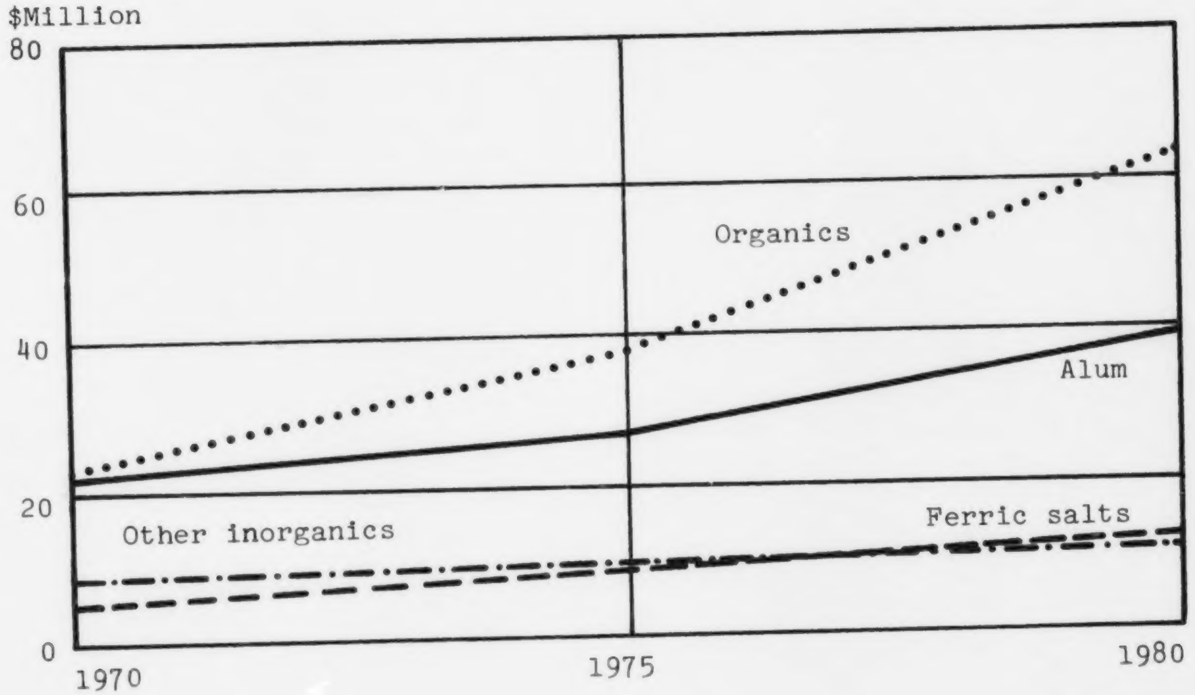

Figure 5-2. Shows water and wastewater treatment chemical sales for coagulants.[a,b]

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[a] A.C. Gross, "Markets for Chemicals Grow and Grow," Environmental Science and Technology, 8(5): 415, May 1974.

[b] No consideration of Interim Primary Drinking Water Regulations implementation and drinking water effluent guidelines in these predictions.

available chlorine and 30 percent inert salt compounds. Other major producers are Pennwalt (15,000 to 16,000 tons/year), and PPG (8,000 to 10,000 tons/year). Production of hypochlorite is presently at capacity since there is a strong demand for its use as a disinfectant in swimming pools. There are a total of six plants in the United States which produce hypochlorite.[1] Due to the present supply and demand balance, price hikes are expected to be forthcoming. Consumption of hypochlorites may reach 300 million pounds by 1980, but a breakdown by industry was not easily available. The total cost of hypochlorites for water treatment is expected to reach an additional $8.2 million by 1980. Delays may occur until production facilities can be expanded. However, the industry is presently expanding to keep pace with anticipated demands.

### 5.1.3 Activated Carbon

Removal of CCE organics from water systems which violate the Proposed Interim Primary Drinking Water Regulations would generally involve adsorption treatment using activated carbon.

It has been estimated that 3.4 percent of all community water systems would need treatment for CCE organics based on violations found in the CWSS study; this amounts to about 160 plants. The initial carbon requirement was developed by assuming a surface application rate of 2 $gpm/ft^2$, a bed depth of 2.5 ft, and a density of 25 $lb/ft^3$. Using these assumptions an initial carbon requirement of 2,045 tons was calculated. If one assumes that systems serving 5,000 or more people will regenerate their carbon (losing 5 percent each regeneration) and regenerations will occur every other month, then 1,676 tons of carbon would be required per year. If regenerations occur monthly, then 3,353 tons would be required per year.

Activated carbon can be utilized in either a granular or powdered form. The granular form is most often utilized in water treatment and is supplied at about 37 to 40 cents per pound (Figure 5-3). Westvaco, by far the largest producer

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[1] Chlorine Institute, North American Chlor-Alkali Industry Plants and Production Data Book (New York, January 1975), p. 5.

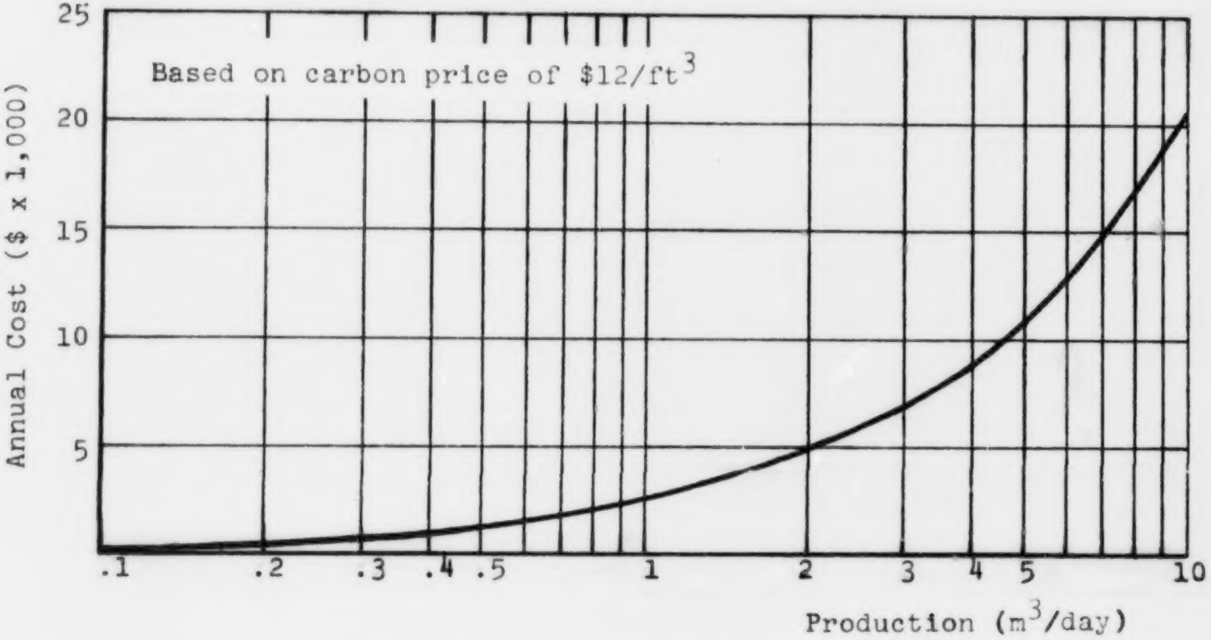

Figure 5-3. This figure shows the carbon replacement costs.

of activated carbon, presently produces granular carbon in quantity and expects to begin on-line manufacture of powdered carbon in quantity by mid-June of 1975. Additional carbon to meet the standards would cost about $4 million per year.

Present production of activated carbon is estimated at about 85,000 tons/year, most of which is manufactured from coal or from animal and vegetable chars. The carbon is activated by treatment with superheated steam or acid to increase its surface area-to-weight ratio, which in turn increases its adsorption capability. (Bone char is made by calcining degreased bones in the absence of air.) Supply of carbon appears to be quite adequate. Reserves are ample for the future and are of minor concern in production of carbon for non-fuel uses.

Activated carbon is used in many pollution control efforts; competition for the available activated carbon could become acute as more pollution abatement takes place.

Major producers are Westvaco, followed by American Norit, Atlas Chemical, Calgon, Barneby-Cheney, National Carbon, Pittsburgh Chemical, and Witco. These manufacturers might need to build several new plants to meet the nearly 6 percent increase in demand which would result from implementation of the new regulations. Again, with this chemical it is necessary that the chemical suppliers be apprised of potential demand caused by implementation of the proposed interim regulations so that demand will not outstrip supply.

### 5.1.4 Projections

Implementation of the Proposed Interim Primary Drinking Water Regulations would place heaviest demands on the coagulant and the disinfectant chemical industries. Projections show that production costs for alum, ferric chlorides, and hypochlorites will be rising in the near future, and that new plants will probably have to be constructed to increase the present near-capacity production of calcium hypochlorite. It is generally believed that the raw materials necessary for the manufacture of these chemicals are abundant, and that U.S. self-sufficiency will abate any major problems in this area.

The increasing demand for pollution control chemicals has caused significant price hikes in the last several years and there is every evidence that this increasing cost trend will continue in the next decade. Table 5-6 shows the projected growth trend for several categories of water treatment chemicals.

## 5.2 Manpower Constraints

### 5.2.1 General

Although it provides a universally required product and is the largest industry in the United States, the water supply industry is facing serious problems of manpower competence and availability. In the present modern, highly urbanized society, water is collected, treated, and delivered in an efficient, reliable manner. This has been made possible through a high degree of functional specialization in the industry's work force, estimated to number about 180,000 (exclusive of persons holding similar positions in consulting engineering, manufacturing, and government).[1]

Non-managerial water utility personnel are classified into 17 categories composed of (1) the nine most common office and supervisory positions, and (2) the eight most common construction, maintenance and service jobs.[2] These categories are further consolidated into five functional categories as shown in Table 5-7.

The level of employment in the water utilities field has been relatively stable for the last 20 years.[3] However, with (1) increased attention on ecological and consumer issues; (2) more stringent requirements on water product quality; (3) rising public demands for better quality water; and (4) technological improvements in the design and operation of water supply facilities, the industry is faced with growing needs for qualified personnel. In order to continue to meet its vital responsibilities, the water

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[1] H.E. Hudson and F. Rodriguez, "Water Utility Personnel Statistics," JAWWA, 62: 8, 1970.

[2] American Water Works Association, "1974 Survey of Water Utilities Salaries, Wages, and Employee Benefits," JAWWA, 67: 7, 1974.

[3] C.M. Schwig, "Training and Recruiting of Water Utility Personnel," JAWWA, 66: 7, 1974.

## TABLE 5-6

## WATER AND WASTEWATER TREATMENT CHEMICALS[a]

| ITEM | 1970 | 1980 | ANNUAL PERCENT CHANGE 1970-80 |
|---|---|---|---|
| MILLION POUNDS | | | |
| Coagulants | 1,326 | 2,085 | 4.6 |
| Filter Media | 556 | 926 | 5.2 |
| pH neutralizers and Salt | 5,950 | 11,925 | 7.2 |
| Biologicals | 993 | 4,427 | 16.2 |
| Internal Preparations | 484 | 870 | 6.1 |
| Total Volume | 9,309 | 20,233 | 8.1 |
| Cents per Pound | 4.1 | 4.7 | 1.4 |
| MILLION DOLLARS | | | |
| Coagulants | 56.7 | 126.0 | 7.6 |
| Filter Media | 48.0 | 115.9 | 9.2 |
| pH Neutralizers and Salt | 64.6 | 152.8 | 9.0 |
| Biologicals | 71.9 | 200.4 | 10.8 |
| Internal Preparations | 143.0 | 348.0 | 9.3 |
| Total Value | 384.2 | 943.1 | 9.4 |
| Industrial and municipal Water Consumption (Tgal) | 95.6 | 146 | 4.3 |
| Lb/M gal | 97 | 139 | 3.6 |
| Gross National Product ($ billion) | 974 | 1,900 | 6.9 |
| Antipollution Chemical Sales/$000 GNP | 0.39 | 0.50 | 2.5 |

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[a] A.C. Gross "Markets for Chemicals Grow and Grow," Environmental Science and Technology, (8)5: 1974, p. 414.

## TABLE 5-7

## WATER UTILITY PERSONNEL CATEGORIES[a]

| FUNCTIONAL CATEGORY | COMPONENT PERSONNEL |
|---|---|
| Production | Plant Operators, Equipment Operators, Maintenance Mechanics |
| Distribution | Foremen, Pipe Fitters, Laborers, Servicemen |
| Consumer Service | Meter Readers, Meter Repairmen |
| Financing | Accountants, Bookkeeping Machine Operators, Cashiers |
| Administration | Superintendents, Clerks, Secretaries, Stenographers, Telephone Operators |

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[a] AWWA, "1974 Survey of Water Utilities Salaries, Wages, and Employee Benefits."

supply industry must have the ability to attract and retain qualified manpower in all functional groups. Manpower has been recognized as the most important element in providing high quality water service.[1]

Manpower difficulties in the industry are the result of growth, automation, and environmental concern. The manpower difficulties are compounded since the industry has historically had trouble attracting personnel due to low wages, salaries, and benefits paid to water utility personnel.[2] Tables 5-8, 5-9, 5-10, 5-11, and 5-12 all show that the wages and benefits paid to water system employees lag behind that of comparably trained personnel in general. Competition for capable personnel is intense in all industries, but is particularly keen among those employing civil, sanitary, and chemical engineers. The history of low-wage policy in the water supply industry has resulted in an inability to attract and retain technically trained people in a competitive labor market.

### 5.2.2 Manpower Availability

New personnel are needed in the water utility industry for three major reasons:

1. Expansion of existing systems and services;
2. Establishment of new systems;
3. Retirement and turnover of present personnel.

Water utilities vary in size from one-man departments to those employing hundreds of people; manpower shortages are therefore selective. In a general sense, however, water utility operation is becoming increasingly complex. The industry must continually provide water service which is indicative not only of the technical competence of professionals in the field, but also of the living standards of the consumers it serves. To do this the industry needs more managers, engineers, chemists, biologists, and other professional persons to fill technical positions. In addition,

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[1] G.H. Dyer, "Manpower: The Important Element in Providing Quality Water Service," JAWWA, 66: 1974.

[2] G.H. Dyer, "Recruiting and Holding Good Employees: Employee Grievance Procedures," JAWWA, 62: 8, 1970.

## TABLE 5-8

## UNITED STATES WATER UTILITY MANAGERS SALARY SURVEYS 1968-1974[a]

| | AVERAGE ANNUAL SALARIES REPORTED | | |
|---|---|---|---|
| | 1968 ($) | 1974 ($) | Percent Increase |
| POPULATION SERVED: | | | |
| <1,000 | 5,778 | 9,347 | 62 |
| >250,000 | 70,500 | 76,625 | 9 |
| AVERAGE SALARIES: | | | |
| All Respondents | 10,540 | 13,818 | 31 |
| Government-Owned | 10,364 | 13,513 | 30 |
| Investor-Owned | 12,182 | 16,420 | 35 |
| (Inv.-Govt.) | (1,818) | (2,907) | |
| Percent Diff. (Using Govt. as base) | 18 | 22 | |

| | QUESTIONNAIRES | | |
|---|---|---|---|
| YEAR | RETURNED | SENT | PERCENT |
| 1968 | 1,500 | 3,500 | 43 |
| 1974 | 2,147 | 4,800 | 45 |

[a] AWWA, "1974 Survey of Water Utilities Salaries, Wages, and Employee Benefits."

TABLE 5-9

UNITED STATES AVERAGE SALARIES AND WAGES (AWWA SURVEYS) AND PERCENTAGE INCREASES, 1968-1974[a]

| Classification | Average Salary or Wage[b] | | | Percentage Increase 1968-1974[c] |
|---|---|---|---|---|
| | Period | 1968 ($) | 1974 ($) | |
| Manager | Annual | 10,540 | 13,818 | 31 |
| Division Superintendent | Weekly | 196 | 223 | 14 |
| Foreman | Weekly | 142 | 202 | 42 |
| Accountant | Weekly | 142 | 206 | 45 |
| Billing Clerk | Weekly | 94 | 145 | 54 |
| Clerk General Office | Weekly | 93 | 137 | 47 |
| Secretary | Weekly | 110 | 152 | 38 |
| Stenographer | Weekly | 104 | 149 | 43 |
| Telephone Operator, Receptionist | Weekly | 93 | 127 | 37 |
| Cashier | Weekly | 91 | 127 | 40 |
| Pipe Fitter | Hourly | 3.03 | 4.38 | 45 |
| Maintenance Mechanic | Hourly | 3.06 | 4.47 | 46 |
| Equipment Operator | Hourly | 2.91 | 4.33 | 49 |
| Laborer | Hourly | 2.27 | 3.67 | 62 |
| Serviceman | Hourly | 2.88 | 4.25 | 48 |
| Meter Repairman | Hourly | 2.91 | 4.23 | 45 |
| Plant Operator | Hourly | 2.91 | 4.24 | 46 |
| Meter Reader | Hourly | 2.65 | 3.90 | 47 |

[a] AWWA, "1974 Survey of Water Utilities Salaries Wages and Employee Benefits."

[b] In 1957 average manager's salary was $5,960; in 1963 it was $8,457.

[c] From 1957 to 1968 increase was 42 percent; from 1963 to 1968 it was 25 percent in manager's salary.

## TABLE 5-10

## MEDIAN WATER UTILITY MAN[illegible]ER SALARIES COMPARED TO MEDIAN SALARIES [illegible]R ENGINEERS IN PUBLIC UTILI[illegible]

| | 1968 | 1974 |
|---|---|---|
| Water Utility Managers Median Salary ($) | 9,831 | 13,803 |
| Public Utilities Engineers Median Salary ($) | 15,952[a] | 19,780[b] |
| Percent Difference | 39 | 30 |

[a] 1969 Median salary as reported in Prof. Engr., 42: 2: 10, February 1972.

[b] 1973 Median salary as reported in NSPC Survey, 1973 (AWWA Report).

## TABLE 5-11

## WATER UTILITY EMPLOYEE BENEFITS, 1974 SURVEY[a]

| TYPE OF BENEFIT | DESCRIPTION |
|---|---|
| Unionism | PERCENT OF UTILITIES HAVING UNION CONTRACTS |

| Ownership | 1969 | 1974 |
|---|---|---|
| Government (G) | 25 | 33 |
| Investor (I) | 29 | 40 |

Trend toward unionization of production, distribution, and maintenance employees.

| TYPE OF BENEFIT | DESCRIPTION |
|---|---|
| Vacation | PERCENT OF UTILITIES OFFERING NOTED VACATIONS |

| Number of Years Employed | Number of Weeks Vacation Two G | Two I | Three G | Three I | Four G | Four I |
|---|---|---|---|---|---|---|
| 1 | 62 | 61 | - | | - | |
| 2 | 86 | 94 | - | | - | |
| 10 | - | | 67 | 76 | - | |
| 15 | - | | 46 | 46 | - | |
| 20 | - | | - | | 55 | 66 |
| 25 | - | | - | | 49 | 45 |

Trend toward longer vacation allowances.

| TYPE OF BENEFIT | DESCRIPTION |
|---|---|
| Sick Leave | Fifteen days allowance per year for more than one year of service is the most accepted practice by both G and I owned utilities. |
| Pensions | PERCENT OF UTILITIES PAYING FULL COST OF PENSION PLAN |

| Ownership | 1969 | 1974 |
|---|---|---|
| Government | 15 | 20 |
| Investor | 50 | 60 |

---

[a] AWWA, "1974 Survey of Water Utilities Salaries, Wages, and Employee Benefits." JAWWA, 67:5, 1974.

TABLE 5-11 (Cont.)

<table>
<tr><th>TYPE OF BENEFIT</th><th>DESCRIPTION</th></tr>
<tr><td>Pensions (Cont.)</td><td>Payment of entire cost of pension plans is becoming more common; investor-owned utilities and utilities in large cities are more likely to pay the entire cost; for utilities having contributory pension plans, a 50-50 balance of employer-employee payment is widely used; private pension plans more common to larger utilities and more likely to include all employees.</td></tr>
<tr><td>Retirement</td><td>PERCENT OF UTILITIES FORCING RETIREMENT AT GIVEN AGE
<table>
<tr><th>Retirement Age</th><th>1969</th><th>1974</th></tr>
<tr><td>65</td><td>47</td><td>53</td></tr>
<tr><td>70</td><td>26</td><td>21</td></tr>
</table></td></tr>
<tr><td>Holidays</td><td>AVERAGE NUMBER OF PAID HOLIDAYS BY UTILITY SIZE
<table>
<tr><th></th><th colspan="2">Population Served</th></tr>
<tr><th>Ownership</th><th><1,000</th><th>>250,000</th></tr>
<tr><td>Government</td><td>7.7</td><td>10.2</td></tr>
<tr><td>Investor</td><td>6.7</td><td>10.2</td></tr>
</table></td></tr>
<tr><td>Overtime</td><td>PERCENT OF UTILITIES NOT HAVING AN OVERTIME PAY POLICY
<table>
<tr><th></th><th>G</th><th>I</th></tr>
<tr><td>For construction, operation and maintenance employees</td><td>3</td><td>8</td></tr>
<tr><td>For supervisory and office personnel</td><td>31</td><td>27</td></tr>
<tr><td>Percent paying 1.5 times regular pay rate</td><td>76</td><td>83</td></tr>
<tr><td>Percent paying 2 times regular pay rate</td><td>1</td><td>2</td></tr>
<tr><td>Percent having guaranteed work week for employees</td><td>43</td><td>33</td></tr>
</table></td></tr>
</table>

TABLE 5-12

## COMPARISON OF U.S. CHAMBER OF COMMERCE[a] AND AWWA EMPLOYEE BENEFITS SURVEYS

| AVERAGE COST OF ALL EMPLOYEE BENEFITS | USCC 1973 | AWWA 1974 |
|---|---|---|
| Percent of Gross Payroll | 39.5 | 33.5 |
| Dollars per Hour Worked | 1.876 | 1.907 |

[a] The Chamber of Commerce survey was based on payroll figures for 1973, one year prior to the AWWA survey.

the level of competence of non-technical personnel must be increased through training and advancement incentives.

Despite high national unemployment rates, the reservoir of unemployed manpower does not include many people required by the water supply industry today.[1] The industry's greatest need is for civil, sanitary, and chemical engineers, who have the lowest incidence of unemployment among engineers. Technical people trained in other disciplines are not attracted by the lower salaries and benefits offered by water utilities. Professionally trained engineers are not needed for every manpower deficit, however. In fact, a major element in the solution of manpower problems would be the utilization of available manpower. Babcock[2] points out that highly technically trained people are not needed in some of the middle levels of water supply systems, and that sources of adequate personnel include (1) junior colleges and universities, (2) training schools, (3) transfers from industry, and (4) in-house advancement. He further notes that "...a successful key to any recruiting program is to campaign at all levels actively, by all people, to bring the salary levels of personnel to reasonable values."[3]

Another aspect of solving the manpower crisis would be the utilization of training and professional improvement programs. Sources of training for water utility personnel include (1) junior colleges, (2) operators associations, (3) commercial-development organizations, (4) in-house programs, and (5) Federal and state programs. Many utilities support professional growth by word; few reward it financially.[4] The lack of adequately trained personnel in the industry would be alleviated by industry-wide support of professional improvement at all levels of employment.

The owners, customers, and regulatory components of the water supply industry must recognize that if it is to provide continued good service, water rates must allow for improved industry salary and benefit policies to interest and motivate qualified people. Reliable and competent personnel are as necessary to the industry as conduits, impoundments, and treatment facilities. People of many different academic and non-academic disciplines would be needed to allow adequate water service to continue in the face of rapid growth. Qualified people can be attracted to and retained by the water supply industry if it (1) gives proper attention to publicizing the advantages of water supply careers; (2) utilizes manpower resources more effectively; and (3) provides salaries and benefits comparable to other utilities and industries.[1]

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[1] Dyer, "Manpower: Important Element in Quality of Water Service," 1974.

[2] R.H. Babcock, "Recruiting - A Proposal for Action," JAWWA, 66: 7, 1974.

[3] Babcock, "Recruiting - A Proposal for Action," 1974.

[4] Schwig, "Training and Recruiting of Personnel," 1974.

### 5.2.3 Personnel Required to Implement Interim Primary Drinking Water Regulations

This section estimates the manpower necessary to implement the Proposed Interim Primary Drinking Water Regulations. The responsibilities of this implementation would encompass all levels of government, Federal, state and local, and many diverse categories of both basic and support services. The professional people involved would include engineers, sanitarians, chemists and microbiologists; these would be supported by technicians, geologists, attorneys, planners, data processing personnel, system analysts, information specialists, educators, and clerical personnel.

For this study, a framework of the activities necessary for the implementation of the regulations was first chosen. Many of these could immediately be deduced from the proposed regulations, while others had to be added based on general requirements attributable to any successful national program. An estimation of the average number of man-years was made; routine task allocations were more easily estimated than non-routine activities, but these estimates can be modified as new data become available. For example, it is difficult to determine the additional amount of monitoring which would be required for those plants which exceed a particular regulation, since it is impossible to predict how long it would take to locate and rectify the source of the contaminant.

### 5.2.4 Monitoring and Enforcing

This section delineates the additional manpower required to do the routine microbiological, radiological, and chemical monitoring and analysis required by the Proposed Interim Primary Drinking Water Regulations. The microbiological manpower requirement is outlined in Table 5-13. Table 5-14 gives a breakdown of laboratory manpower requirements for chemical monitoring for community systems, while Table 5-15 gives the same information for non-community systems. It is assumed that no manpower is presently performing the chemical analyses required by the proposed regulations.

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[1] Dyer, "Manpower: Important Element in Water Service," 1974.

One additional component of the monitoring and surveillance costs is associated with state surveillance of drinking water systems. Jeffrey estimates that 4 man-days of field time per system are required annually to accomplish this task for community systems, and 1 man-day for each non-community system.[1] This amounts to 360,000 man-days or 1,636.4 man-years to examine all community drinking water systems. Table 5-16 gives a breakdown by states of the number of field personnel presently assigned to accomplish this surveillance. In addition, Table 5-16 tabulates the number of laboratory personnel in each state. Of the 19 states which supplied information on inspectors, the average was 7.1 inspectors per state, or a projected national total of 358 surveillance personnel. This means that over four times the present number of surveillance personnel would be necessary to adequately monitor the interim regulations.

### 5.2.5 Operation of New and Retrofit Process Equipment

Implementation of the regulations would uncover many systems which require installation of treatment instrumentation and its concomitant requirements of operational personnel. The exact requirements of manpower would vary from system to system, depending on the sophistication of the equipment and the amount of production. For example, chlorination units need a minimum of daily surveillance; ion exchange needs daily surveillance, backwash, and either regeneration or replacement. The total estimated manpower required is 15,969 man-years (Table 5-17). Table 5-18 shows the average number of employees presently employed for different treatment systems by population served.

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[1] E.A. Jeffrey, "Water Supply Training and Manpower Needs," Journal of New England Water Works Association (Washington, D.C., June 1972).

TABLE 5-13

## MICROBIOLOGICAL STAFFING REQUIREMENTS

| POPULATION RANGE | AVERAGE[a] POPULATION SERVED | NUMBER OF SYSTEMS | NUMBER OF COLIFORM ANALYSIS[b] (1,000) | NUMBER OF PLATE COUNT[b] (1,000) | MANPOWER REQUIREMENT[c] (man-years) (220/day/year) |
|---|---|---|---|---|---|
| 25-99 | 60 | 7,008 | 168 | 84 | 71.6 |
| 100-499 | 250 | 15,113 | 363 | 181 | 154.5 |
| 500-999 | 700 | 5,392 | 129 | 65 | 55.1 |
| 1,000-2,499 | 1,500 | 5,182 | 124 | 62 | 52.8 |
| 2,500-4,999 | 3,400 | 2,605 | 125 | 31 | 44.3 |
| 5,000-9,999 | 6,800 | 1,858 | 178 | 22 | 56.8 |
| 10,000-99,999 | 23,633 | 2,599 | 956 | 103 | 300.8 |
| 100,000-999,999 | 242,700 | 236 | 391 | 39 | d |
| ≥1,000,000 | 3,074,800 | 7 | 37 | 3 | d |
|  |  | 40,000 |  |  | 735.9 |
|  | 25[e] | 200,000 | 4,800,000 | 2,400,000 | 2,045.5 |
|  | ADDITIONAL MANPOWER REQUIRED FIRST YEAR: |  |  |  | 2,781.4 |

[a] Assuming present average population in nine population ranges.

[b] Use required number of analyses per population served.

[c] Assume 0.5 man-hours per sample. This includes sample collection, analysis, and reporting.

[d] Assume this monitoring is presently being done.

[e] For 200,000 systems serving non-community public -- assume operate 12 months and only serve 25 people.

TABLE 5-14

LABORATORY MANPOWER REQUIREMENTS -- NATIONWIDE MONITORING OF COMMUNITY SYSTEMS

| COMPONENT | ANALYSIS[a,b] MAN-YEAR | ANALYSES[c] REQUIRED NATIONWIDE FIRST TWO YEARS | | | | THIRD YEAR | MAN-YEARS OF ANALYTICAL EFFORT FIRST | SECOND | THIRD |
|---|---|---|---|---|---|---|---|---|---|
| | | Routine | Violator[d] | Near Violator | Total | Routine | | | |
| As | 4,400 | 25,100 | 1,965 | 270 | 27,335 | 20,200 | 6.2 | 6.2 | 4.6 |
| Ba | 6,600 | 25,100 | 660 | 0 | 25,760 | 20,200 | 3.9 | 3.9 | 3.1 |
| Cd | 2,200 | 25,100 | 2,625 | 9,700 | 37,425 | 20,200 | 17.0 | 17.0 | 9.2 |
| Cr | 6,600 | 25,100 | 1,965 | 7,500 | 34,565 | 20,200 | 5.2 | 5.2 | 3.1 |
| $CN^-$ | 2,200 | 25,100 | 0 | 0 | 25,100 | 20,200 | 11.4 | 11.4 | 9.2 |
| $F^-$ | 6,600 | 25,100 | 23,445 | 11,900 | 60,445 | 20,200 | 9.2 | 9.2 | 3.1 |
| Pb | 2,200 | 25,100 | 3,930 | 12,200 | 41,230 | 20,200 | 18.7 | 18.7 | 9.2 |
| Hg | 4,400 | 25,100 | 7,245 | 10,800 | 43,145 | 20,200 | 9.8 | 9.8 | 4.6 |
| $NO_3^-$ | 6,600 | 25,100 | 14,535 | 5,950 | 45,585 | 20,200 | 6.9 | 6.9 | 3.1 |
| Se | 4,400 | 25,100 | 5,595 | 22,900 | 53,595 | 20,200 | 12.2 | 12.2 | 4.6 |
| Ag | 6,600 | 25,100 | 0 | 0 | 25,100 | 20,200 | 3.8 | 3.8 | 3.1 |
| CCE | 660 | 25,100 | 2,370 | 270 | 27,740 | 20,200 | 42.0 | 42.0 | 31.0 |
| **Pesticides & Herbicides** | 198 | | 0 | 0 | 25,100 | 20,200 | 126.8 | 126.8 | 102.0 |
| | | | | Total Metals | | | 76.8 | 76.8 | 41.5 |
| | | | | Total $F^-$ + $CN^-$ + $NO_3^-$ | | | 27.5 | 27.5 | 15.4 |
| | | | | Total Organic | | | 168.8 | 168.8 | 133.0 |
| | | | | Total | | | 273.1 | 273.1 | 189.9 |

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[a] Personal communication E. McFarren and H. Nash, EPA Cincinnatti, June 1975.

[b] Personal communication J. Dice - Denver Board of Water Commissioners, March 1975.

[c] Estimates based on 1969 CWSS study.

[d] Assuming an average of 30 analyses for each violation.

TABLE 5-15

## LABORATORY MANPOWER REQUIREMENTS NATIONWIDE FOR NON-COMMUNITY SYSTEMS

| COMPONENT | ANALYSES[a,b] MAN-YEAR | ANALYSES[c] REQUIRED NATIONWIDE EACH OF FIRST SIX YEARS | | | | MAN-YEARS OF ANALYTICAL EFFORT |
|---|---|---|---|---|---|---|
| | | Routine | Violator | Near Violators | Total | |
| As | 4,400 | 33,333 | 17,316 | 3,996 | 54,645 | 12.4 |
| Ba | 6,600 | 33,333 | 17,316 | 3,996 | 54,645 | 8.3 |
| Ca | 2,200 | 33,333 | 17,316 | 3,996 | 54,645 | 24.8 |
| Cr | 6,600 | 33,333 | 17,316 | 3,996 | 54,645 | 8.3 |
| $CN^-$ | 2,200 | 33,333 | 17,316 | 3,996 | 54,645 | 24.8 |
| $F^-$ | 6,600 | 33,333 | 17,316 | 3,996 | 54,645 | 8.3 |
| Pb | 2,200 | 33,333 | 17,316 | 3,996 | 54,645 | 24.8 |
| Hg | 4,400 | 33,333 | 17,316 | 3,996 | 54,645 | 12.4 |
| $No_3^-$ | 6,600 | 33,333 | 17,316 | 3,996 | 54,645 | 8.3 |
| Se | 4,400 | 33,333 | 17,316 | 3,996 | 54,645 | 12.4 |
| Ag | 6,600 | 33,333 | 17,316 | 3,996 | 54,645 | 8.3 |
| CCE | 660 | 33,333 | 17,316 | 3,996 | 54,645 | 83.0 |
| Pesticides | 198 | 33,333 | 17,316 | 3,996 | 54,645 | 276.0 |
| | | | | | TOTAL ANALYTICAL SERVICES | 512.1 |

[a] Personal communication with E. McFarren and H. Nash, EPA Cincinnati, June 1975.

[b] Personal communication with J. Dice -- Denver Board of Water Commissioners, March 1975.

[c] Asumming that one-sixth of the 200,000 systems comply each year and 1 percent are found to be between 75 and 100 percent of maximum and therefore must monitor monthly.

## TABLE 5-16

## SANITARY INSPECTORS AND LABORATORY PERSONNEL BY STATE

| | NUMBER OF INSPECTORS | NUMBER OF LABORATORY PERSONNEL |
|---|---|---|
| ALABAMA | | |
| ALASKA | N | N |
| ARIZONA | 8 | N |
| ARKANSAS | | |
| CALIFORNIA | N | 35 |
| COLORADO | 5 | 5.75 |
| CONNECTICUT | 3 | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 8 | 13 |
| HAWAII | N | 2 |
| IDAHO | 2 | 3 |
| ILLINOIS | | |
| INDIANA | 3 | 11 |
| IOWA | 12 | N |
| KANSAS | 3 | 2.5 |
| KENTUCKY | N | 3.5 |
| LOUISIANA | | |
| MAINE | 1 | 9 |
| MARYLAND | | |
| MASSACHUSETTS | | |
| MICHIGAN | 14 | 4 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 3 | 2.5 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | 4 | N |
| NEW MEXICO | N | N |
| NEW YORK | N | N |
| NORTH CAROLINA | 18 | N |
| NORTH DAKOTA | N | N |
| OHIO | 18 | 22 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | 4 | 9 |
| SOUTH CAROLINA | N | 15 |
| SOUTH DAKOTA | | |
| TENNESSEE | | |
| TEXAS | 25 | 44 |
| UTAH | 1 | N |
| VERMONT | | |
| VIRGINIA | N | N |
| WASHINGTON | N | N |
| WEST VIRGINIA | 0 | 2.5 |
| WISCONSIN | | |
| WYOMING | 4 | 1.5 |

N is not known.

No entry indicates lack of response.

## TABLE 5-17

## PERSONNEL TO OPERATE NEW AND RETROFIT PROCESS EQUIPMENT

| TREATMENT | NUMBER OF ADDITIONAL SYSTEMS | EMPLOYEES PER SYSTEM (man-years) | TOTAL ADDITIONAL EMPLOYEES NEEDED |
|---|---|---|---|
| Chlorination | 5,557 | 0.5 | 2,778.5 |
| Activated Carbon | 162 | 1 | 162 |
| Clarification | 2,126 | 4 | 8,504 |
| Ion Exchange | 2,481 | 1 | 2,481 |
| Activated Alumina | 1,702 | 1 | 1,702 |
| pH Control | 684 | 0.5 | 342 |
| Total additional process personnel required for community systems | | | 15,969.5 |
| Total additional process personnel required public non-community systems | | | 3,409[a] |
| TOTAL | | | 19,378.5 |

[a] Assume one-fourth of 200,000 systems require some minimal treatment of 15 man-days per year.

TABLE 5-18

## AVERAGE NUMBER OF EMPLOYEES FOR DIFFERENT TREATMENT[a,b]
PUBLICLY-OWNED

| POPULATION | COAG. | FILT. | DIS. | SOFT | COR. CONT. | NONE | |
|---|---|---|---|---|---|---|---|
| 25-99 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Average No. of Employees<br>No. of Systems |
| 100-499 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 500-999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 1,000-2,499 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 2,500-4,999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 5,000-9,999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 10,000-99,999 | 31.82<br>39. | 29.26<br>46 | 53.86<br>74 | 32.11<br>12 | 27.90<br>25 | 15.32<br>14 | Ave. No. Emp.<br>No. Systems |
| 100,000-999,999 | 265.82<br>11 | 244.47<br>14 | 197.15<br>20 | 150.67<br>3 | 244.56<br>10 | -<br>- | Ave. No. Emp.<br>No. Systems |
| > 1,000,000 | 938.83<br>2 | 938.83<br>2 | 1,521.22<br>3 | -<br>- | 938.83<br>2 | -<br>- | Ave. No. Emp.<br>No. Systems |

[a] American Water Works Association, "Operating for Water Utilities 1970 & 1965."

[b] Fractions occur since part time employees are counted as 0.66 employees.

TABLE 5-18 (cont.)

AVERAGE NUMBER OF EMPLOYEES FOR DIFFERENT TREATMENT[a,b]
INVESTOR-OWNED

| POPULATION | COAG. | FILT. | DIS. | SOFT | COR. CONT. | NONE | |
|---|---|---|---|---|---|---|---|
| 25-99 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Average No. of Employees<br>No. of Systems |
| 100-499 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 500-999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 1,000-2,499 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 2,500-4,999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 5,000-9,999 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |
| 10,000-99,999 | 21.44<br>3 | 22.33<br>2 | 18.92<br>9 | -<br>- | -<br>- | 13.59<br>9 | Ave. No. Emp.<br>No. Systems |
| 100,000-999,999 | 67.00<br>1 | 156.83<br>2 | 126.16<br>4 | -<br>- | 78.50<br>2 | -<br>- | Ave. No. Emp.<br>No. Systems |
| > 1,000,000 | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | -<br>- | Ave. No. Emp.<br>No. Systems |

[a] American Water Works Association, "Operating for Water Utilities 1970 & 1965."

[b] Fractions occur since part time employees are counted as 0.66 employees.

TABLE 5-18 (cont.)

AVERAGE NUMBER OF EMPLOYEES FOR DIFFERENT TREATMENT[a,b]
TOTAL[c]

| POPULATION | COAG. | FILT. | DIS. | SOFT | COR. CONT. | NONE | |
|---|---|---|---|---|---|---|---|
| 25-99 | - | - | - | - | - | - | **Average No. of Employees** |
| | - | - | - | - | - | - | No. of Systems |
| 100-499 | - | - | - | - | - | - | **Ave. No. Emp.** |
| | - | - | - | - | - | - | No. Systems |
| 500-999 | - | - | - | - | - | - | **Ave. No. Emp.** |
| | - | - | - | - | - | - | No. Systems |
| 1,000-2,499 | - | - | - | - | - | - | **Ave. No. Emp.** |
| | - | - | - | - | - | - | No. Systems |
| 2,500-4,999 | - | - | - | - | - | - | **Ave. No. Emp.** |
| | - | - | - | - | - | - | No. Systems |
| 5,000-9,999 | - | 17.81 | 16.96 | 14.86 | 15.12 | 22.40 | **Ave. No. Emp.** |
| | - | 30 | 57 | 7 | 17 | 16 | No. Systems |
| 10,000-99,999 | 31.08 | 28.97 | 25.82 | 31.28 | 27.91 | 21.99 | **Ave. No. Emp.** |
| | 42 | 48 | 85 | 12 | 25 | 23 | No. Systems |
| 100,000-999,999 | 249.28 | 177.47 | 246.31 | 150.67 | 173.79 | - | **Ave. No. Emp.** |
| | 12 | 16 | 24 | 3 | 12 | - | No. Systems |
| > 1,000,000 | 938.83 | 938.83 | 1521.22 | - | 938.83 | - | **Ave. No. Emp.** |
| | 2 | 2 | 3 | - | 2 | - | No. Systems |

[a] American Water Works Association, "Operating for Water Utilities 1970 & 1965."

[b] **Fractions occur since part time employees are counted as 0.66 employees.**

[c] Includes not coded plants.

### 5.2.6 Program Assistance

This facet of the overall implementation program would be necessary to provide adequate training for local utility managers, sanitarians, and other water supply personnel. The National Sanitation Foundation estimates that implementation would require 1.4 man-days/year/system for each of the community systems and 0.1 man-days/year for the non-community systems.[1]

### 5.2.7 Program Administration

Program administration would be the final key element in effective implementation of the Interim Primary Drinking Water Regulations. This segment can be broken down into management, planning, and public information. Table 5-19 shows the total administrative manpower required for implementation.

Sixty-six percent of the personnel which would be required to implement the regulations are process personnel who would run the treatment plants at the local level. It is expected that the demand for these process employees would begin in 1979 and that one-fifth of the total number would be employed each succeeding year for the following 5 years.

The 14 percent of the personnel involved in monitoring and 4.4 percent involved in surveillance would be required by July of 1976; the remaining personnel would be employed between 1976 and 1984.

## 5.3 Laboratory Constraints

One of the factors which would determine the success of the monitoring required under the Proposed Interim Primary Drinking Water Regulations is the availability of laboratory facilities which have been certified by the states. This section examines the availability of these facilities, as well as institutional constraints which would either encourage or discourage the use of specific laboratories.

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[1] National Sanitation Foundation, Staffing and Budgetary Guidelines for State Drinking Water Supply Agencies (Ann Arbor, Michigan, May 1974), p. 17.

## TABLE 5-19

## SUMMARY OF MANPOWER REQUIRED TO IMPLEMENT THE PRIMARY DRINKING WATER REGULATIONS

| FUNCTION | RESPONSIBLE AGENCY | | | TOTAL |
|---|---|---|---|---|
| | STATE | LOCAL[d] (man-years) | FEDERAL | |
| Monitoring | | | | |
| microbiological[a] | 2,086 | 695 | 0 | 2,781 |
| chemical[a] | 589 | 196 | 0 | 785 |
| turbidity | 0 | 505 | 0 | 505 |
| Surveillance | 959 | 0 | 319 | 1,278 |
| Process Operation | 0 | 19,378 | 0 | 19,378 |
| Program Assistance | 282 | 0 | 94 | 376 |
| Clerical[b] | 862 | 694 | 91 | 1,647 |
| Program Administration[c] | 392 | 2,077 | 41 | 2,510 |
| TOTAL | 5,170 | 23,545 | 545 | 29,260 |

[a] Assumes state will do three-fourths of the monitoring and local agency one-fourth.

[b] Assumes one clerical person for every five non-process personnel.

[c] Assumes one administrator for every ten non-clerical employees.

[d] Local means water system personnel or municipal employee.

Table 5-20 shows the number of laboratories presently certified to perform organic, inorganic, bacteriological, and turbidity analyses on a state-by-state basis. The information on this table was collected from a 1975 ERCO survey of the states (Appendix B). (Of the 34 states responding, only 12 states had one or more laboratories certified to do inorganic analyses. Eight states had one or more laboratories certified to do organic and pesticide analyses. Twenty-six states had one or more laboratories certified to do bacteriological analyses. Three states had a program to certify turbidimeters.) The results of this study indicate that at the present time no state has an active certification program which would enable rapid compliance with Section 141.27 of the proposed regulations. It is possible, however, that many states would be able to certify enough laboratories by December 1976 to allow monitoring to proceed. It is essential that the states develop rational reporting and record keeping procedures so that this task will not become onerous for the laboratories.

Tables B-1 to B-10 of Appendix B show the percentages of each analysis which are performed in in-house, private, commercial, municipal and state laboratories in each state, as well as the capacity and present usage of the state laboratories. These tables indicate that the great majority of the analyses are done in state laboratories and that the majority of state laboratories are presently working at or near capacity.

Table 5-21 shows the manner in which costs for use of the laboratory facilities are presently being allocated by the states. Twenty of the 25 states responding pay 50 percent or more of the costs of the analysis; it is therefore highly unlikely that municipal facilities would send their samples to a private laboratory where the municipality would have to pay the full price of the analysis. If the states continue their present policy of subsidizing laboratories, it is apparent that most state laboratory facilities would have to be expanded at least tenfold if the regulations were implemented. The alternatives available to the states include the following:

1. Dropping the subsidy;

2. Doing only partial analyses of each system, for example, only inorganic analyses;

3. Increasing laboratory facilities;

## TABLE 5-20

## LAB CERTIFICATION BY STATE

| | INORGANIC | | | | ORGANIC | | | | BACTERIOLOGICAL | | | | TURBIDITY | RESIDUAL CHLORINE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | In-House | Pri. | Mun. | St. | In-House | Pri. | Mun. | St. | In-House | Pri. | Mun. | St. | | |
| ALABAMA | | | | | | | | | | | | | | |
| ALASKA | N | N | N | N | N | N | N | N | N | N | N | N | NO | NO |
| ARIZONA | N | N | N | 1 | N | N | N | 1 | N | N | N | N | NO | NO |
| ARKANSAS | | | | | | | | | | | | | | |
| CALIFORNIA | 101 | 107 | 88 | 3 | 23 | 107 | 36 | 2 | 33 | | 160 | 21 | NO | NO |
| COLORADO | | | | | | | | | | | | | | |
| CONNECTICUT | | | | | | | | | | | | | | |
| DELAWARE | | | | | | | | | | | | | | |
| DISTRICT OF COLUMBIA | | | | | | | | | | | | | | |
| FLORIDA | N | N | N | N | N | N | N | N | N | N | N | 7 | NO | NO |
| GEORGIA | N | N | N | N | N | N | N | N | N | N | N | N | NO | NO |
| HAWAII | 1 | N | N | 1 | 1 | N | N | 1 | 1 | N | N | 4 | NO | NO |
| IDAHO | N | N | N | 1 | N | N | N | 1 | N | 1 | N | 5 | NO | NO |
| ILLINOIS | N | N | N | N | N | N | N | N | 15 | 9 | 14 | 7 | NO | NO |
| INDIANA | N | N | N | N | N | N | N | N | 30 | 17 | 3 | N | NO | NO |
| IOWA | N | N | N | 1 | N | N | N | 1 | N | 3 | 18 | 2 | NO | NO |
| KANSAS | N | N | N | N | N | N | N | N | 5 | N | 2 | N | NO | NO |
| KENTUCKY | N | N | N | N | N | N | N | N | 15 | 3 | 4 | 2 | NO | NO |
| LOUISIANA | | | | | | | | | | | | | | |
| MAINE | N | N | N | N | N | N | N | N | 5 | 2 | N | 1 | NO | YES |
| MARYLAND | N | N | N | N | N | N | N | N | 10 | 0 | 0 | 9 | NO | NO |
| MASSACHUSETTS | | | | | | | | | | | | | | |
| MICHIGAN | N | N | N | N | N | N | N | N | 107 | 2 | N | 4 | NO | YES |
| MINNESOTA | | | | | | | | | | | | | | |
| MISSISSIPPI | | | | | | | | | | | | | | |
| MISSOURI | | | | | | | | | | | | | | |
| MONTANA | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| NEBRASKA | 1 | N | 3 | 3 | N | N | N | N | 1 | N | 3 | 3 | NO | NO |
| NEVADA | | | | | | | | | | | | | | |
| NEW HAMPSHIRE | | | | | | | | | | | | | | |
| NEW JERSEY | N | N | N | N | N | N | N | N | 33* | 31* | 9 | N | NO | NO |
| NEW MEXICO | N | N | N | 1 | N | N | N | 1 | N | N | N | 1 | NO | NO |
| NEW YORK | | | | | | | | | | | | | | |
| NORTH CAROLINA | 16 | N | 2 | 1 | N | N | N | 1 | 16 | N | 2 | 1 | NO | NO |
| NORTH DAKOTA | N | N | N | N | N | N | N | N | 3 | N | 1 | 6 | NO | NO |
| OHIO | 2 | N | N | 1 | N | N | N | 1 | 147 | 22 | N | 22 | YES | YES |
| OKLAHOMA | 50 | N | 100 | 1 | 1 | N | 1 | N | 4 | N | 4 | 1 | NO | NO |
| OREGON | | | | | | | | | | | | | | |
| PENNSYLVANIA | N | N | N | N | N | N | N | N | 80 | 185 | 80 | 3 | | |
| RHODE ISLAND | N | N | N | N | N | N | N | N | 8 | 5 | N | 3 | NO | NO |
| SOUTH CAROLINA | 113 | 1 | N | 1 | N | N | N | N | 78 | 1 | N | 5 | YES | YES |
| SOUTH DAKOTA | | | | | | | | | | | | | NO | NO |
| TENNESSEE | | | | | | | | | | | | | | |
| TEXAS | N | N | N | N | N | N | N | N | 46 | N | N | 26 | NO | NO |
| UTAH | N | 4 | N | 1 | N | N | N | 1 | N | 1 | 5 | 1 | NO | NO |
| VERMONT | N | N | N | N | N | N | N | N | N | N | N | N | YES | YES |
| VIRGINIA | | | | | | | | | | | | | | |
| WASHINGTON | N | N | N | N | N | N | N | N | 5 | 4 | 17 | 1 | NO | NO |
| WEST VIRGINIA | | | | | | | | | | | | | | |
| WISCONSIN | | | | | | | | | | | | | | |
| WYOMING | N | N | N | N | N | N | N | N | 1 | 1 | 1 | 1 | NO | NO |

*Ohio "pending" and have approval in 6 months.

*N.J. 46 in-house, private are uncertified.

N means no answer

## TABLE 5-21

## PERCENTAGE OF TOTAL MONITORING COSTS BY STATE

| | LOCAL WATER SYSTEM | MUNICIPAL SYSTEM | STATE AGENCY |
|---|---|---|---|
| ALABAMA | | | |
| ALASKA | 10 | 40 | 50 |
| ARIZONA | 90 | | 10 |
| ARKANSAS | | | |
| CALIFORNIA | 80 | 20 | 0 |
| COLORADO | N | N | N |
| CONNECTICUT | N | N | N |
| DELAWARE | | | |
| DISTRICT OF COLUMBIA | | | |
| FLORIDA | N | N | N |
| GEORGIA | 0 | 10 | 90 |
| HAWAII | N | N | N |
| IDAHO | 0 | 0 | 100 |
| ILLINOIS | 13 | 2 | 85 |
| INDIANA | 5 | 0 | 95 |
| IOWA | N | N | N |
| KANSAS | 40 | 0 | 60 |
| KENTUCKY | 20 | 10 | 70 |
| LOUISIANA | | | |
| MAINE | 50 | 50 | 0 |
| MARYLAND | 0 | 0 | 100 |
| MASSACHUSETTS | | | |
| MICHIGAN | 0 | 0 | 100 |
| MINNESOTA | | | |
| MISSISSIPPI | | | |
| MISSOURI | | | |
| MONTANA | N | N | N |
| NEBRASKA | 10 | 20 | 70 |
| NEVADA | | | |
| NEW HAMPSHIRE | | | |
| NEW JERSEY | varies with supply | | |
| NEW MEXICO | 0 | 0 | 100 |
| NEW YORK | N | N | N |
| NORTH CAROLINA | $15-$64 based on sales | $15-$64 | >50% |
| NORTH DAKOTA | 0 | 0 | 100 |
| OHIO | 0 | 0 | 100 |
| OKLAHOMA | 0 | 0 | 100 |
| OREGON | | | |
| PENNSYLVANIA | N | N | N |
| RHODE ISLAND | N | N | N |
| SOUTH CAROLINA | each pay their own way | | |
| SOUTH DAKOTA | 5 | 85 | 10 |
| TENNESSEE | | | |
| TEXAS | 10 | 0 | 90 |
| UTAH | 10 | 20 | 70 |
| VERMONT | | | |
| VIRGINIA | 5 | 0 | 95 |
| WASHINGTON | 0 | 0 | 100 |
| WEST VIRGINIA | 0 | 0 | 100 |
| WISCONSIN | | | |
| WYOMING | 0 | 46 | 54 |

N is not known.
No entry means lack of response.

4. Selectively analyzing specific groups of systems, for example, only those which serve 1,000 or fewer people.

In an effort to estimate the amount of coliform testing presently being done in industries other than the drinking water supply industry, ERCO looked at the compliance schedules for selected food industries and municipal wastewater treatment facilities. The monitoring frequencies, number of plants, and number of coliform analyses presently being performed are listed in Table 5-22, as is the additional coliform monitoring required by the Proposed Interim Primary Drinking Water Regulations. The additional monitoring mandated by the regulations is approximately 15 percent of the monitoring presently being done in these three industries. However, it is anticipated that the private sector could supply ample facilities to handle the increased laboratory load if economic incentives justify the expansion of existing facilities.

ERCO surveyed several major laboratories which specialize in organic and inorganic water analyses and found one laboratory which stated that with minimal staff additions it could perform the entire additional chemical monitoring load anticipated under the regulations. Based on this response it is felt that more than ample facilities are available to perform all chemical analyses required by the interim drinking water regulations.

It appears that the major constraint on laboratories is the lack of adequate state certification programs.

## 5.4 Construction Constraints

This section explores the capability of construction and engineering industries to design and build the treatment facilities which would be required under the regulations. New public utilities construction involves many long-term projects and is expected to continue upward growth.

Table 5-23 shows the trends in new construction for the last four years. The estimated \$1.1 to \$1.8 billion required under the regulations to upgrade the nation's drinking water supply systems would be spread over 5 years and would therefore represent an additional outlay of less than 0.2 percent of the present total annual new construction.

## TABLE 5-22

## PRESENT COLIFORM MONITORING TO MEET EFFLUENT GUIDELINE LIMITATIONS

| INDUSTRY | SAMPLING FREQUENCY | NUMBER OF PLANTS | NUMBER OF COLIFORM ANALYSES PRESENTLY PERFORMED/YEAR |
|---|---|---|---|
| FOOD PRODUCTS[a] | | | |
| 1-10 mgd | one per week | 4,000 | 208,000 |
| 10-50 mgd | three times per week | 550 | 85,800 |
| WASTEWATER TREATMENT | | | |
| <0.99 mgd | one per month | 16,200 | 194,400 |
| 1-4.99 mgd | one per week | 10,200 | 530,400 |
| 5-14.99 mgd | five times weekly | 3,600 | 936,000 |
| TOTAL | | | 1,954,600 |
| Projected coliform monitoring requirement to implement Interim Primary Drinking Water Regulations for community water supplies | | | 2,547,397 |
| Present coliform monitoring being done for community water supplies | | | 1,961,621 |
| Additional coliform monitoring mandated by Interim Primary Drinking Water Regulations | | | 585,776 |

[a] Marketing Economics Institute, Limited., Marketing Economics Industry Key Plants, 1973; includes plants employing over 100 people.

## TABLE 5-23

### NEW CONSTRUCTION PUT IN PLACE: TRENDS AND PROJECTIONS 1972-74[a]
(In Billions of Dollars)

| TYPE OF CONSTRUCTION | 1972 | 1973 | 1974[b] | 1973-74 PERCENT CHANGE | 1975[b] | 1974-75 PERCENT CHANGE |
|---|---|---|---|---|---|---|
| Total new construction | 124.1[c] | 135.4[c] | 133.7 | -1 | 149.5 | 12 |
| Private - total | 93.9 | 102.9 | 98.2 | -5 | 111.5 | 14 |
| Public - total | 30.2 | 32.6 | 35.5 | 9 | 38.0 | 7 |
| Residential buildings (private and public) | 55.2 | 58.5 | 49.7 | -15 | 58.5 | 18 |
| Nonresidential buildings (private and public) | 34.7 | 39.6 | 43.0 | 9 | 45.7 | 6 |
| Industrial | 5.2 | 6.8 | 7.8 | 15 | 8.5 | 9 |
| Commercial | 13.5 | 15.5 | 16.5 | 6 | 17.5 | 6 |
| Educational | 6.7 | 7.5 | 7.8 | 4 | 8.4 | 8 |
| Hospital | 4.2 | 4.2 | 4.4 | 5 | 4.5 | 2 |
| All other | 5.1 | 5.7 | 6.5 | 14 | 6.8 | 5 |
| Farm | 1.4 | 2.1 | 1.6 | -24 | 1.6 | 0 |
| Public utilities (private and public) | 13.2 | 14.7 | 17.0 | 16 | 19.5 | 15 |
| Telephone | 3.3 | 4.0 | 4.5 | 13 | 5.0 | 11 |
| Electric | 7.6 | 8.3 | 9.4 | 13 | 10.5 | 12 |
| All other | 2.3 | 2.4 | 3.1 | 29 | 4.0 | 29 |
| Highways | 10.4 | 10.6 | 11.7 | 10 | 12.5 | 7 |
| Military | 1.1 | 1.2 | 1.4 | 17 | 1.5 | 7 |
| Conservation and development | 2.2 | 2.3 | 2.4 | 4 | 2.5 | 4 |
| Sewer and water | 2.8 | 3.2 | 3.4 | 6 | 4.0 | 18 |
| All other (public and private) | 3.2 | 3.4 | 3.5 | 3 | 3.7 | 6 |

[a] Bureau of the Census and Bureau of Domestic Commerce.

[b] Estimated by Bureau of Domestic Commerce.

[c] Detail does not add to total due to rounding.

Since the amount of construction required to upgrade drinking water systems is small compared to national expenditures, it is anticipated that engineering and construction resources would be sufficient to implement the regulations. The building of water supply facilities, however, requires specialized design and construction engineering. A 1972 survey[1] showed that there were only about 940 firms nationwide which were employed in the design of water and wastewater treatment plants. These firms employed approximately 50,000 full- and part-time personnel and were spread across the country with a low of 37 firms in EPA Region VIII, and a high of 189 firms in Region V. Since this trade is so specialized and the number of firms is limited, it is possible that some rural communities would have difficulty locating services on a timely basis.

### 5.4.1 Building Materials

Although construction activity increased, several major building materials came into short supply during 1974; in particular, insulation, asphalt, fabricated structural steel, reinforcing steel, various types of underground pipe, precast and prestressed concrete, and metal doors and windows. While many of these spot shortages have been resolved, it is possible that they could recur.

Another factor which could influence construction of needed treatment system facilities would be recurrence of gasoline and diesel fuel shortages, such as those which disrupted some construction activity during the latter part of 1973 and 1974.

A final construction constraint could be the availability of cement and concrete. (There are 50 companies operating 170 Portland cement plants in the United States.) Since 1972 the industry has been operating at well over 90 percent of rated capacity, and it is expected that demand will outgrow capacity increases through the rest of this decade.[2]

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[1] U.S. Environmental Protection Agency, Office of Water Programs, by E. Joe Middlebrooks, A National Survey of Manpower Utilization and Future Needs of Consulting Engineering Firms Employed in Water Pollution Control (Logan, Utah, 1972), p. 2.

[2] U.S. Department of Commerce, U.S. Industrial 1975 Outlook (Washington, D.C., 1975), p. 27.

# CHAPTER SIX

# FEASIBILITY OF FINANCING COSTS

## 6.0 Introduction

Compliance with the proposed interim regulations set by the EPA under the Safe Drinking Water Act would require several types of expenditures by suppliers of drinking water. Expenses for manpower and equipment for monitoring (sampling and analysis), operation and maintenance, capital costs for water treatment, and indirect costs including those for administration would all have to be met in some way by all water suppliers: large, small, public (generally, municipally-owned), and private (investor-owned). In order to ascertain who would pay these costs, several aspects of the present financial situation of water utilities have to be analyzed, including: indebtedness through bonds; rates charged for water sales; and relationships with local, state, and Federal governments. This chapter aggregates all costs developed in previous chapters of this report and explores the financial effect on the impacted systems.

## 6.1 Present Industry Financial Structure

Although a majority of all community water systems today have debt ratios ranging upward from 40 percent, almost one-fourth are free of long-term debt. Approximately 85 percent of these debt-free systems serve communities of less than 5,000 people.[1] However, these debt-free small systems are not necessarily the most financially sound. Income tax returns of water and sanitary systems analyzed in the Almanac of Business and Industrial Financial Ratios (1975 edition) show that almost half of the small investor-owned systems failed to show a positive net income (Table 6-1).

Many larger water utilities that appear to be saddled with high debt may actually be slightly better off. Compared with other types of utilities, water systems tend to have high debt ratios (ratios of long-term debt to the book value of property). This is not surprising due to the large

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[1] R.C. Hyle, "Rate Philosophy," JAWWA, 63, (11): 685, November 1971.

## TABLE 6-1

## FINANCIAL STRUCTURE OF INVESTOR-OWNED WATER SYSTEMS AND RELATED SERVICES[a]

| SIZE OF ASSETS | NUMBER OF FIRMS | NUMBER REPORTING NET LOSS | NET PROFIT BEFORE TAX AS PERCENT OF SALES |
|---|---|---|---|
| A TOTAL | 6,649 | 2,820 | 5.4 |
| B Under $100 | 4,472 | 2,160 | 3.8 |
| C $100 to $250 | 1,157 | 419 | 2.2 |
| D $250 to $500 | 548 | 133 | 6.1 |
| E $500 to $1000 | 234 | 39 | 8.2 |
| F $1000 to $5000 | 182 | 63 | Net Loss for Category |
| G $5000 to $10.000 | 19 | 4 | 4.5 |
| H $10,000 to $25,000 | 17 | 2 | 7.5 |
| I $25,000 to $50,000 | 6 | - | 10.8 |
| J $50,000 to $100,000 | 8 | - | 6.5 |
| K $100,000 to $250,000 | 5 | - | 16.3 |
| L $250,000 and over | 1 | - | Net Loss for Category |

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[a] _Almanac of Business and Industrial Financial Ratios (1975 Edition)_ (Englewood Cliffs, New Jersey: Prentice-Hall Publishing Company, 1975).

capital expenditures required compared to the low product cost of water. Since many areas have statutory limitations on total indebtedness for public utilities and ceilings on interest rates, some water utilities would be able to absorb only a limited amount of further capital expenditure if financed by traditional means.

Matters are further complicated by the existence of loan covenants, particularly coverage ratios. Coverage ratios for water utilities are generally defined by the formula:

$$\text{Coverage} = \frac{\text{Net Revenues}}{\text{Debt Service}}$$

where Debt Service = Interest and Principal Repayments

Unless utilities seeking additional funds are well above their normally required coverage ratios -- which usually range near 1.5[1] -- they may well be forced to finance with higher interest loans or more expensive common stock (for the investor-owned utilities).

Most utilities, both public and private, finance large capital investments by retaining profits and acquiring debt. Government-owned water utilities usually have access to municipal funds and can sell either general obligation bonds, to be repaid from general revenues (including property taxes), or revenue bonds, which are less secure since they are repaid from water revenues only.

Investor-owned utilities issue stock as well as bonds, and their credit ratings are more completely dependent on the profitability of their own operations. Unbacked by governmental guarantees and tax-exempt status of municipal utilities, their debt -- particularly their common stock -- is more risky than the debt issues of government-owned utilities. Since interest rates are proportional to risk, utilities in more secure financial positions can borrow money more easily and at lower interest rates. Government-owned utilities have the advantage that their credit may be more highly rated. At the present time the interest rate on municipal bonds is 4 to 6 percent while the rate for private (investor-owned) utilities is 6 to 8 percent.[1]

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[1] John D. Wright and Don R. Hassall, "Trends in Water Financing," in Modern Water Rates (8th edition) edited by Elroy Spitzer (American City Magazine, 1972).

In some localities, the public water system has historically not been 100 percent self-sustaining. That is, the utilities do not meet all operating and financing costs with revenues derived from rates; in certain cases these costs are met with general tax revenues. However, because of the increasing demand for local tax dollars there is a trend toward self-sustaining water utilities. Indeed, some cities and towns have levied general fund assessments against publicly-owned water utilities, forcing them to assume the costs of other municipal services.[2] Municipal loans to private corporations and utilities for pollution control and treatment are allowed in some states, but courts in other states have ruled that this assistance is unconstitutional.[3] These trends have caused water rates to increase in recent years.

Capital investments required by the new regulations would be financed heavily by new bond issues. For some this would pose no problem; others, already deeply in debt or without the necessary credit rating, might have difficulty in meeting the new costs. The Safe Drinking Water Act provides for guaranteed Federal loans up to $50,000 for "small" public water systems, including both public and private utilities. Although the guaranteed loans of $50,000 under the Act ease the transition to full compliance with the proposed interim primary regulations, they may well prove to be insufficient alone, particularly for those systems requiring ion exchange (Table 6-2). Medium-sized water utilities might need larger amounts of money and might not be able to obtain the full amounts through bond issues and loans not covered by the $50,000 loan guarantee provision.

In addition to capital investments, other costs would be incurred to meet the more rigorous drinking water regulations, especially for increased monitoring and laboratory analysis of water samples for inorganics, organics, pesticides, and biological contaminants. Although many large water utilities

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[1] Personal communication -- First National Bank of Boston, April 1975.

[2] Hyle, "Rate Philosophy," p. 687.

[3] Public Works, February 1975, p. 116.

TABLE 6-2

## CAPITAL COSTS FOR A MODEL WATER SYSTEM SERVING 250 PEOPLE

| TREATMENT | CAPITAL COST ($) |
|---|---|
| Clarification | 30,000 |
| Ion Exchange | 68,000 |
| Activated Carbon | 4,300 |
| Activated Alumina | 6,100 |
| Chlorination | 1,200 |

presently have their own laboratory facilities and personnel for monitoring activities, analyses would have to be performed for more contaminants and more frequently. Many states now provide laboratory services for water analysis at a subsidized price; if state facilities could not be expanded rapidly enough to meet the increased needs, private laboratories might be able to fill the gap. In any case, new equipment would be needed for tests which are not now performed; the water utilities would have to absorb the costs of analysis into their operating budgets or pass the costs on to the states through the use of subsidized state and private laboratories.

All increased operating costs for monitoring and for additional treatment, and all increased payments of interest and principal on (new) loans and bonds, would eventually have to be met directly through increased revenues, indirectly through funds from state and local tax revenues, or from Federal grants (also tax revenues). Private utilities might be able to meet increased operating expenses by retaining more earnings rather than distributing earnings to investors in the form of dividends; however, this practice would tend to hurt their financial position by decreasing the value of their stock. Hence, it is not an appropriate long-term financial strategy.

Since the major source of revenue for most water utilities is the sale of water to customers, the issue of rates (or prices) is relevant. Public water systems which have their own collection facilities but do not sell water, such as restaurants, hotels, and filling stations, would probably meet increased costs by raising the prices of other commodities; in most other cases, increased water rates would be necessary.

A National Association of Water Companies (NAWC) study[1] claims that residential sales account for 61 percent of the income of the 105 reporting plants (Table 6-3), while a study by the AWWA[2] claims that residential sales account for only 38 percent of the income of their 768 reporting

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[1] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities" (Washington, D.C., 1973).

[2] American Water Works Association, "Operating Data for Water Utilities: 1970-1975" (New York).

TABLE 6-3

WATER SALES BY TYPE OF CUSTOMER[a]

| TYPE OF CUSTOMER | NUMBER OF CUSTOMERS | MILLIONS OF GALLONS SOLD | REVENUES ($) |
|---|---|---|---|
| Residential | 2,458,800<br>(90.77)[c] | 199,507<br>(44.44) | 182,463,467<br>(61.85) |
| Industrial | 206,069<br>(7.61) | 85,037<br>(18.94) | 56,213,05<br>(19.05) |
| Commercial | 16,316<br>(.60) | 122,356<br>(27.25) | 24,138,443<br>(8.18) |
| Other | 27,600<br>(1.02) | 42,049<br>(9.37) | 32,210,638[b]<br>(10.92) |
| TOTAL | 2,708,784<br>(100.00) | 448,949<br>(100.00) | 295,025,604<br>(100.00) |

[a] Based on reports of 105 companies.

[b] Includes fire protection revenues of $14,923,081 (5.00).

[c] Numbers in parentheses are percentages.

Source: National Association of Water Companies, 1973.

utilities. These differences in residential income are presumably due to differences in the sizes of the reporting systems in the two studies. Seven of the companies of the NAWC study serve average populations of under 1,000 people while none of the systems in the AWWA study serve under 1,000 people. Many of the 28,500 systems serving under 1,000 people serve only residential customers.

Because of greater risk, lack of tax-exempt status, and lack of direct and indirect subsidies, the investor-owned companies have a higher cost of capital; thus the investor-owned companies generally charge higher rates per unit than do public systems (Figure 6-1). Rates also vary among systems which have different amounts of treatment.

Prices to the consumer are determined by rate structures, which in turn are a function of the institutional status of the consumer (i.e., industrial, commercial, or residential) and are also a function of the cost of producing water. There are basically four types of rate structure:

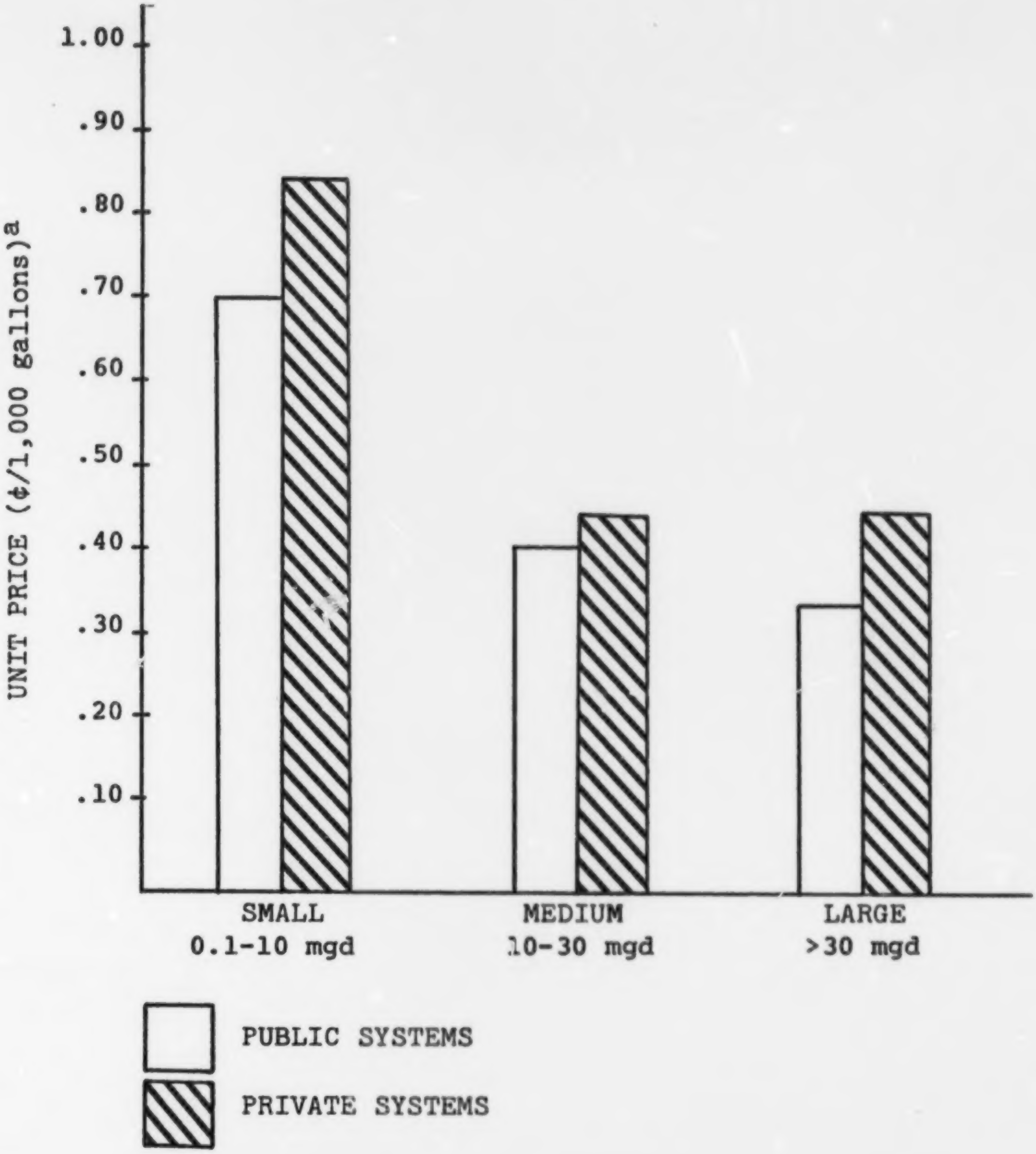
1. Normal block structure
2. Inverted block structure
3. Flat rate structure
4. Non-incremental rate structure

Normal block structure applies particularly to industrial consumers and it gives a lower unit cost to the users of higher volumes.

The inverted rate structure assigns higher unit costs to the largest consumers. The rationale behind this structure is that it encourages conservation through the economic incentive of raising prices to larger users.

Only a small portion of all water supply utilities are currently using the flat rate structure. This method utilizes a single charge per unit for both large and small consumers.

Non-incremental rate structures are used to charge consumers when their water is not metered; basically, the unit cost of water is dependent on the number of taps or of water consumption units of equipment (i.e., toilets, faucets, etc.) owned by the user.



[a]There are 0.00378 $m^3$ per gallon.

Figure 6-1. This figure shows the unit price of water in ¢/1,000 gallons.

No significant correlation exists between system size and rate structure. Nor does type of ownership -- public vs. private -- appear to influence type of rate structure employed.

Prices charged for water are usually regulated by a state or local commission appointed to evaluate the need for rate hikes. Investor-owned utilities in all but two states are under the jurisdiction of state regulatory commissions. Public utilities are either regulated by local boards or are unregulated. Under such local control, water utilities formulate rate schedules to provide the gross revenues approved by the commissions.

The Eastern states control their water supply utilities more stringently than do the Western states. This reflects the general degree of state government control over commerce in the country. Public Utilities Commissions (PUC's) in the West provide a liaison between the consumers and the utilities by arranging public hearings for proposed rate hikes; in general, rate increases are seldom denied in this region of the nation.

The situation appears to be quite different in the East. A good example is Connecticut, where the PUC regulates only investor-owned companies. The Connecticut PUC is a five-member board, appointed by the governor and supported by a staff of engineers and technical/clerical personnel. They generally approve between 10 and 60 percent of utility-proposed rate hikes per year for the water supply industry.

A common pitfall for many regulatory commissions in the investigation of proposed water supply utility rate increases is their historical viewpoint in assessing the validity of rate requests. For instance, it is not uncommon for a PUC to review a private supplier's financial history of the previous year in determining its profit. Basically, the assumption is:

Revenue - Expenditures = Profit

If this profit seems unreasonable, relative to other utilities' profit margins or relative to past margins, the proposed increase is not likely to be approved. Many utilities are required to submit annual financial reports for just such purposes.

Increased public understanding of water quality as a result of the Safe Drinking Water Act is expected to impress public regulatory agencies with the need for capital investments in the water supply industry. This process, in turn, should aid those plants requiring additional funds for compliance with the effluent guidelines.

## 6.2 Characteristics of Demand for Water

### 6.2.1 Trends in Demand

Some of the many factors influencing trends in water use are: the level of water and sewer service; changes in customer bills for those services; changes in modes of living; the growth and nature of business, industry, and institutional services; annual variations in the local economy as well as the long-term state of the local economy; changes in climate; the extent of existing service-area development and redevelopment; the ability to extend service to additional areas; and the availability of an adequate high-quality water supply.[1]

Table 6-4 shows projections of the municipal water requirements by the Water Resources Council; they indicate that water requirements will double between 1965 and 1980.

### 6.2.2 Uses of Treated Water

Public water supply systems provide water service for residential, commercial, industrial and general municipal purposes. An approximate allocation of the water supplied by water utilities to various categories of users is shown in Table 6-5.

Non-revenue producing water results from the following practices:

1. Ten gallons per 150 gallons on the average are lost due to system losses such as leakage and evaporation;
2. Flushing of fire control systems.

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[1] W.L. Patterson, "Water Use," JAWWA, 65: 287 (Denver, Colorado, 1973).

TABLE 6-4

## PROJECTIONS OF MUNICIPAL WATER REQUIREMENTS[a]

(Millions of gallons per day)

| | CONSUMPTION | | | |
|---|---|---|---|---|
| | 1965 | 1980 | 2000 | 2020 |
| North Atlantic | 905 | 1,210 | 1,750 | 2,550 |
| South Atlantic Gulf | 363 | 600 | 1,000 | 1,500 |
| Great Lakes | 502 | 702 | 953 | 1,304 |
| Ohio | 230 | 300 | 430 | 620 |
| Tennessee | 46 | 64 | 95 | 140 |
| Upper Mississippi | 162 | 258 | 403 | 580 |
| Lower Mississippi | 175 | 238 | 343 | 497 |
| Souris-Red Rainy | 11 | 16 | 26 | 35 |
| Missouri | 221 | 280 | 339 | 397 |
| Arkansas-White-Red | 241 | 496 | 832 | 1,205 |
| Texas Gulf | 400 | 740 | 1,200 | 1,750 |
| Rio Grande | 108 | 220 | 400 | 670 |
| Upper Colorado | 14 | 30 | 35 | 50 |
| Lower Colorado | 203 | 310 | 515 | 840 |
| Great Basin | 94 | 154 | 255 | 345 |
| Columbia-North Pacific | 182 | 219 | 350 | 537 |
| California | 1,320 | 4,620 | 7,350 | 11,300 |
| Alaska | 7 | 24 | 46 | 75 |
| Hawaii | 39 | 65 | 106 | 173 |
| Puerto Rico | 21 | 35 | 50 | 75 |
| TOTAL | 5,244 | 10,581 | 16,478 | 24,643 |

[a] Water Resources Council, "The Nation's Water Resources," (Washington, D.C., 1968), p. 4-1-3.

TABLE 6-5

COMMUNITY WATER SUPPLY USE BY CATEGORY

| TYPE OF USE | PERCENTAGE OF TOTAL |
|---|---|
| Residential | 63 |
| Commercial | 11 |
| Industrial | 21 |
| Municipal | 5 |
| TOTAL | 100 |

Source: U.S. Geological Survey estimates, 1972.

### 6.2.3 Elasticity of Demand

Records indicate that water use per customer tends to decrease following significant increases in water rates. Howe and Linaweaver[1] estimate the price elasticity of demand for water at -0.23 for metered, public sewer areas. Gottlieb[2] found it to be -0.4 in large cities and -0.65 in smaller communities. In an article by the American Water Works Association[3] (AWWA) the implied elasticities are -0.08, -0.20, -0.22, -0.28, -0.33 and -0.34. These elasticities mean that for a given percent price increase, water use will decrease by a much smaller percentage (Table 6-6). For example, if the elasticity is -0.23 and the price of water increases by 20 percent the use of water will decrease by only 4.6 percent. This means that the water companies' revenue will increase as the elasticity increases.

The elasticity for water used for lawn sprinkling is much greater than the elasticity for water in general. Howe and Linaweaver[4] found the sprinkling elasticity to be -0.7 in the arid West and -1.6 in the humid East. This indicates that if the price of water increases, people reduce the amount of sprinkling. Gottlieb's high elasticity (-0.65) may be due to sprinkling demands. This elasticity was estimated for small towns, which tend to have more space devoted to lawns and gardens than large cities. Thus the amount of area devoted to lawns and gardens in a utility district will affect consumer response to price increases.

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[1] Charles W. Howe and F.P. Linaweaver, Jr., "The Impact of Price on Residential Water Demand and Its Relation to System Design and Price Structure," Water Resources Research, 3: 1, First Quarter 1967.

[2] M. Gottlieb, "Urban Domestic Demand for Water: A Kansas Case Study," Land Economics, May 1968.

[3] American Water Works Association, Committee of Water Use, "Water Use Committee Report," JAWWA, May 1973.

[4] Howe and Linaweaver, "Impact of Price on Demand and Its Relation to Design and Structure," 1967.

## TABLE 6-6

## THE RELATIONSHIP BETWEEN PRICE CHANGES AND QUANTITIES OF WATER PURCHASED AS A FUNCTION OF PRICE ELASTICITY

| PRICE ELASTICITY OF DEMAND FOR WATER | PERCENT DECREASE IN DEMAND FOR WATER | | | |
|---|---|---|---|---|
| | DUE TO 5 PERCENT INCREASE IN PRICE | DUE TO 20 PERCENT INCREASE IN PRICE | DUE TO 50 PERCENT INCREASE IN PRICE | DUE TO 100 PERCENT INCREASE IN PRICE |
| -0.08 | 0.4 | 1.6 | 4.0 | 8.0 |
| -0.20 | 1 | 4.0 | 10.0 | 20.0 |
| -0.22 | 1.1 | 4.4 | 11.0 | 22.0 |
| -0.23 | 1.15 | 4.6 | 11.5 | 23.0 |
| -0.28 | 1.4 | 5.6 | 14.0 | 28.0 |
| -0.33 | 1.65 | 6.3 | 16.5 | 33.0 |
| -0.34 | 1.7 | 6.8 | 17.0 | 34.0 |
| -0.40 | 2.0 | 8.0 | 20.0 | 40.0 |
| -0.65 | 3.25 | 13.0 | 32.5 | 65.0 |

Technology also plays a role in determining consumption. The examples that resulted in the AWWA elasticities of -0.20 and -0.34 were instances where the population was able to convert from water-cooled air conditioners to non-water-using air conditioners. Once a price increase causes people to change their habits and buy water-saving appliances it is not clear that a further price increase will cause further reductions of water use.

Table 6-7 indicates the manner in which revenue will change as a function of elasticity and price change. To determine the change in demand and revenue as a result of a price increase for a particular utility, several factors must be considered:

1. How much area is devoted to lawns and gardens?
2. How prevalent are water-using appliances such as water-cooled air conditioners?
3. To some extent the total level of cost appears to influence water use in all classes of service. In areas where the average cost to residential customers was $0.60 to $0.70/1,000 gallons, customer use averaged approximately 70 percent of use in areas where the cost was $0.20 to $0.30/1,000 gallons. These figures result in an elasticity of -0.28. Therefore utilities considering moves from the lower to higher price range should expect an elasticity of -0.28.

The above factors will determine the relevant elasticity for a utility, and thus the expected demand and revenue changes. As Table 6-7 indicates, total revenue increases everywhere with water price increases, except when price elasticity is -0.65 and price increases 100 percent or greater. This means that if a water company, located in an area where lawn sprinking is prevalent, doubles its rate it may actually end up with less revenue than before the rate increase.

## 6.3 Distribution of Costs

### 6.3.1 General

This section explores how treatment and monitoring costs would be distributed over the next 10 years. This

## TABLE 6-7

## THE RELATIONSHIP BETWEEN REVENUE AND PRICE CHANGE AS A FUNCTION OF ELASTICITY

| PRICE ELASTICITY OF DEMAND FOR WATER | PERCENT INCREASE IN REVENUE | | | |
|---|---|---|---|---|
| | DUE TO 5 PERCENT INCREASE IN PRICE | DUE TO 20 PERCENT INCREASE IN PRICE | DUE TO 50 PERCENT INCREASE IN PRICE | DUE TO 100 PERCENT INCREASE IN PRICE |
| -0.08 | 4.6 | 18.1 | 44.0 | 84.0 |
| -0.20 | 3.95 | 15.1 | 35.0 | 60.0 |
| -0.22 | 3.8 | 14.7 | 33.5 | 56.0 |
| -0.23 | 3.8 | 14.5 | 32.7 | 54.0 |
| -0.28 | 3.5 | 13.3 | 29.0 | 44.0 |
| -0.33 | 3.4 | 12.4 | 25.3 | 34.0 |
| -0.34 | 3.2 | 11.8 | 24.5 | 32.0 |
| -0.40 | 2.9 | 10.4 | 20.0 | 20.0 |
| -0.65 | 1.6 | 4.4 | 1.3 | -30.0 |

cost distribution is displayed by size of system, treatment facilities and type of ownership. The underlying assumptions used in developing these costs are shown in Chapter Four, Sections 4.1 and 4.10.

### 6.3.2 Annual Monitoring Costs

The effective date of the proposed regulations is July 1976; at this time the monitoring activity will begin. The projected annual monitoring costs for the first two years after implementation would be approximately $109 million per annum, then drop to an annual expenditure rate of approximately $100 million after the fifth year (Table 6-8).

Non-community systems would account for 69.7 percent of monitoring costs during the first year, while 43 percent of the community systems' monitoring costs would be borne by systems serving 1,000 or fewer people.

### 6.3.3 Annual Capital Costs

In developing the figures for annual capital expenditure (Tables 6-9 through 6-14) it is assumed that no construction will begin until 1978, since it is also assumed that no treatment facility design will begin until after the finalized primary regulations are promulgated in March 1977. In general, a design period of 1.5 years would be needed before construction, and construction would take from one to three years. It is assumed that the capital costs will be spread evenly over five years. In all calculations in this chapter treatment costs are based on average daily production rates.

Clarification units for surface-water systems would account for almost 35 percent of the required capital costs, followed by mercury with 22 percent. Ion exchange treatment for nitrate is the next most costly process (Table 6-11).

The private (investor-owned) segment of the water supply industry would pay 21.5 percent of the total treatment costs while the public sector would pay 79.5 percent (Tables 6-9, 6-10 and 6-11).

Yet this does not necessarily mean that the burden will fall most heavily on the public sector. Systems serving under 100 people -- those with relatively high costs of capital and relatively poor operating records -- are

TABLE 6-8

ANNUAL MONITORING COSTS[a]
(Millions of Dollars Unless Otherwise Noted)

| SYSTEM SIZE | NUMBER OF SYSTEMS | POPULATION SERVED MILLION PEOPLE | 1976 | 1977 | 1978 | 1979 | 1980 | COST PER YEAR 1981-1985 | AVE. COST PER YEAR PER SYSTEM | AVE. COST PER YEAR PER CAPITA |
|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 7,008 | 0.4 | 3.5 | 3.7 | 3.1 | 3.0 | 3.0 | 3.0 | 423.60 | 7.42 |
| 100-499 | 15,113 | 3.8 | 7.7 | 8.0 | 6.9 | 6.6 | 6.6 | 6.6 | 436.83 | 1.74 |
| 500-999 | 5,392 | 3.8 | 2.8 | 2.9 | 2.5 | 2.4 | 2.4 | 2.4 | 453.24 | 0.64 |
| 1,000-2,499 | 5,182 | 7.8 | 2.8 | 2.9 | 2.6 | 2.5 | 2.5 | 2.5 | 474.33 | 0.32 |
| 2,500-4,999 | 2,605 | 8.9 | 1.9 | 2.0 | 1.9 | 1.8 | 1.8 | 1.8 | 679.02 | 0.20 |
| 5,000-9,999 | 1,858 | 12.6 | 2.0 | 2.1 | 1.9 | 1.9 | 1.9 | 1.9 | 1,048.40 | 0.15 |
| 10,000-99,999 | 2,599 | 61.4 | 8.6 | 8.8 | 8.7 | 8.6 | 8.6 | 8.6 | 3,321.53 | 0.14 |
| 100,000-999,999 | 236 | 57.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 3.3 | 13,984.26 | 0.06 |
| >1.000,000 | 7 | 21.5 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 0.3 | 44,939.00 | 0.01 |
| TOTAL COMMUNITY[c] | 40,000 | 177.5 | 32.9 | 34.0 | 31.2 | 30.4 | 30.4 | 30.4 | | |
| TOTAL NON-COMMUNITY[c] | 200,000 | | 75.8 | 75.8 | 75.8 | 75.8 | 75.8 | 69.5 | | |
| TOTAL[c] | 240,000 | | 108.7 | 109.8 | 107.0 | 106.2 | 106.2 | 99.9 | | |

[a] Totals are based on mean costs.

[b] Based on 1981 monitoring costs.

[c] Totals may not add due to rounding.

Assumptions used to partition special monitoring costs by years:

1. Surface systems divide special monitoring evenly between Year 1 and Year 2.
2. Groundwater systems divide special monitoring; 25 percent in Year 1, 50 percent in Year 2, and 25 percent in Year 3.
3. Pesticides and CCE are found only in surface-water.
4. Nitrate, arsenic, barium, cadmium, chromium and fluoride are found only in groundwater.
5. Lead, mercury, and selenium are found in both surface- and groundwater in a random manner.
6. Cyanide and silver are not found in violation.
7. Non-community systems will spread their costs evenly for the first 5 years.

TABLE 6-9

## TOTAL ANNUAL CAPITAL EXPENDITURES[a] BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1971 | 1980 | 1981 | 1982 | 1983 | TOTAL | TOTAL CAPITAL EXPENDITURES PER SYSTEM (DOLLARS)[b] | TOTAL CAPITAL EXPENDITURES PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 1,265 | 16,390,692 | 62.44 | 62.44 | 62.44 | 62.44 | 62.44 | 312.2 | 246,705 | 19.05 |
| CCE | 96 | 1,597,324 | 3.71 | 3.71 | 3.71 | 3.71 | 3.71 | 18.5 | 192,317 | 11.61 |
| $NO_3$ | 579 | 1,667,500 | 35.53 | 35.53 | 35.53 | 35.53 | 35.53 | 177.7 | 306,765 | 106.54 |
| CHLORINATION | 3,308 | 9,556,782 | 7.02 | 7.02 | | | | 14.0 | 4,243 | 1.47 |
| MERCURY | 458 | 2,162,502 | 39.99 | 39.99 | 39.99 | 39.99 | 39.99 | 199.9 | 436,807 | 92.45 |
| SELENIUM | 227 | 604,464 | 14.20 | 14.20 | 14.20 | 14.20 | 14.20 | 71.0 | 313,194 | 117.50 |
| CADMIUM | 105 | 250,860 | 5.87 | 5.87 | 5.87 | 5.87 | 5.87 | 29.4 | 278,695 | 117.04 |
| LEAD | 407 | 1,330,435 | .45 | .45 | .45 | .45 | .45 | 2.3 | 5,534 | 1.69 |
| FLUORIDE | 933 | 2,669,518 | 4.66 | 4.66 | 4.66 | 4.66 | 4.66 | 23.3 | 24,977 | 8.67 |
| CHROMIUM | 80 | 188,145 | 4.65 | 4.65 | 4.65 | 4.65 | 4.65 | 23.2 | 291,231 | 123.46 |
| BARIUM | 28 | 62,712 | 1.67 | 1.67 | 1.67 | 1.67 | 1.67 | 8.3 | 298,011 | 132.94 |
| ARSENIC | 80 | 188,145 | .38 | .38 | .38 | .38 | .38 | 1.9 | 23,861 | 10.12 |
| TOTAL COMMUNITY CAPITAL COSTS[c] | | | 180.56 | 180.56 | 173.55 | 173.55 | 173.55 | 681.8 | | |

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[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-10

## TOTAL ANNUAL CAPITAL EXPENDITURES[a] BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 861 | 2,712,679 | 13.44 | 13.44 | 13.44 | 13.44 | 13.44 | 67.2 | 78,072 | 24.77 |
| CCE | 66 | 264,359 | .80 | .80 | .80 | .80 | .80 | 4.0 | 60,860 | 15.10 |
| $NO_3$ | 394 | 275,973 | 7.65 | 7.65 | 7.65 | 7.65 | 7.65 | 38.2 | 97,078 | 138.55 |
| CHLORINATION | 2,249 | 1,581,969 | 1.51 | 1.51 | | | | 3.0 | 1,343 | 1.91 |
| MERCURY | 311 | 357,897 | 8.61 | 8.61 | 8.61 | 8.61 | 8.61 | 43.0 | 138,231 | 120.23 |
| SELENIUM | 154 | 100,039 | 3.06 | 3.06 | 3.06 | 3.06 | 3.06 | 15.3 | 99,113 | 152.80 |
| CADMIUM | 72 | 41,518 | 1.26 | 1.26 | 1.26 | 1.26 | 1.26 | 6.3 | 88,195 | 152.20 |
| LEAD | 277 | 220,189 | .10 | .10 | .10 | .10 | .10 | .5 | 1,751 | 2.20 |
| FLUORIDE | 635 | 445,118 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 5.0 | 7,904 | 11.27 |
| CHROMIUM | 54 | 31,138 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 5.0 | 92,162 | 160.55 |
| BARIUM | 19 | 10,379 | .36 | .36 | .36 | .36 | .36 | 1.8 | 94,308 | 172.67 |
| ARSENIC | 54 | 31,138 | .08 | .08 | .08 | .08 | .08 | .4 | 7,551 | 13.15 |
| TOTAL COMMUNITY CAPITAL COSTS[c] | | | 38.86 | 38.86 | 37.35 | 37.35 | 37.35 | 189.8 | | |

[a] Assumes: (1) Debt service of 11 percent/year; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-11

TOTAL ANNUAL CAPITAL EXPENDITURES[a] BY TREATMENT PROCESS
(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL[a] | TOTAL PER PLANT (DOLLARS) | TOTAL PER CAPITA (DOLLARS) |
|---|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 2,126 | 19,103,371 | 75.87 | 75.87 | 75.87 | 75.87 | 75.87 | 379.4 | 178,444 | 19.86 |
| CCE | 162 | 1,861,683 | 4.51 | 4.51 | 4.51 | 4.51 | 4.51 | 22.5 | 139,104 | 12.10 |
| $NO_3$ | 973 | 1,943,473 | 43.18 | 43.18 | 43.18 | 43.18 | 43.18 | 215.9 | 221,865 | 111.09 |
| CHLORINATION | 5,557 | 11,140,771 | 8.53 | 8.53 | | | | 17.1 | 3,069 | 1.53 |
| MERCURY | 769 | 2,520,399 | 48.59 | 48.59 | 48.59 | 48.59 | 48.59 | 243.0 | 315,945 | 96.40 |
| SELENIUM | 381 | 704,503 | 17.26 | 17.26 | 17.26 | 17.26 | 17.26 | 86.3 | 226,535 | 122.51 |
| CADMIUM | 177 | 292,378 | 7.14 | 7.14 | 7.14 | 7.14 | 7.14 | 35.7 | 201,582 | 122.03 |
| LEAD | 684 | 1,550,624 | .55 | .55 | .55 | .55 | .55 | 2.7 | 4,003 | 1.77 |
| FLUORIDE | 1,566 | 3,134,636 | 5.67 | 5.67 | 5.67 | 5.67 | 5.67 | 28.3 | 18,066 | 9.04 |
| CHROMIUM | 134 | 219,283 | 5.65 | 5.65 | 5.65 | 5.65 | 5.65 | 28.2 | 210,649 | 128.72 |
| BARIUM | 47 | 73,091 | 2.03 | 2.03 | 2.03 | 2.03 | 2.03 | 10.1 | 215,553 | 138.61 |
| ARSENIC | 134 | 219,283 | .46 | .46 | .46 | .46 | .46 | 2.3 | 17,259 | 10.55 |
| TOTAL COMMUNITY CAPITAL COSTS[a] | | | 219.43 | 219.43 | 210.90 | 210.90 | 210.90 | 1071.5 | | |

[a] Totals may not add due to rounding.

concentrated in the private sector. Indeed, in this group of small companies capital expenditures by investor-owned utilities are three times those of government-owned utilities (Tables 6-12, 6-13, and 6-14).

Table 6-11 shows that the most expensive treatment methodology is ion exchange, when capital costs are calculated on a per capita basis. Capital costs per capita vary from $138.61 for barium removal to $1.53 for chlorination.

Mercury removal is the most expensive capital treatment on a per plant basis. The per plant expenditures vary from $315,945 for mercury removal to $3,069 for chlorination.

Table 6-14 shows that systems serving between 25 and 99 people require an average per capita capital expenditure of almost $163 to treat their water, while systems serving more than 1,000,000 people require only $8.78, on the average.

### 6.3.4 Annual Operation and Maintenance Costs

It is assumed that O&M costs will begin concurrently with capital costs and will aggregate yearly until an equilibrium is reached at the end of the fifth year. Tables 6-15, 6-16, and 6-17 show that the major O&M costs would be for clarification, mercury and nitrate treatment.

The investor-owned companies would pay an annual O&M cost of $45.6 million after 5 years (Table 6-16), while the public utilities would pay $211.8 million in 1983 (Table 6-15).

Likewise, private rather than public companies must bear a higher proportion of the bills of O&M costs for the small water companies. When all costs are included, the private sector's portion of the bill for systems serving 100 or fewer persons is over three times that of the public sector (Tables 6-18, 6-19, and 6-20).

The most costly O&M treatments on a per plant basis are for clarification and ion exchange. The range in per plant costs is from $88,700 for clarification to $184 for lead treatment (Table 6-17). On a per capita basis the most expensive treatment is $11.70 for barium, while the cost to treat for lead is the lowest ($0.08).

Each person served by systems serving between 25 and 99 people will pay an average of approximately $12.00 per year

TABLE 6-12

TOTAL ANNUAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL[a] | TOTAL PER PLANT (DOLLARS) | TOTAL PER CAPITA (DOLLARS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 678 | 41,160 | 1.42 | 1.42 | 1.29 | 1.29 | 1.29 | 6.7 | 9,898 | 162.96 |
| 100-499 | 2,845 | 739,227 | 11.14 | 11.14 | 10.33 | 10.33 | 10.33 | 53.3 | 18,725 | 72.07 |
| 500-999 | 1,206 | 869,941 | 7.67 | 7.67 | 7.46 | 7.46 | 7.46 | 38.1 | 31,592 | 43.81 |
| 1,000-2,499 | 1,233 | 1,695,474 | 11.68 | 11.68 | 11.17 | 11.17 | 11.17 | 56.9 | 46,130 | 30.00 |
| 2,500-4,999 | 624 | 2,151,027 | 18.65 | 18.65 | 17.96 | 17.96 | 17.96 | 91.2 | 146,213 | 42.40 |
| 5,000-9,999 | 393 | 2,675,272 | 21.10 | 21.10 | 20.40 | 20.40 | 20.40 | 103.4 | 263,149 | 38.65 |
| 10,000-99,999 | 540 | 12,958,226 | 69.17 | 69.17 | 66.91 | 66.91 | 66.91 | 339.1 | 628,424 | 26.17 |
| 100,000-999,999 | 46 | 10,364,150 | 30.44 | 30.44 | 29.41 | 29.41 | 29.41 | 149.1 | 3,275,357 | 14.39 |
| >1,000,000 | 2 | 5,010,761 | 8.80 | 8.80 | 8.80 | 8.80 | 8.80 | 44.0 | 22,000,000 | 8.78 |
| TOTAL PUBLICLY-OWNED COMMUNITY CAPITAL COSTS[a] | 7,566 | 36,705,277 | 180.28 | 180.28 | 173.73 | 173.73 | 173.73 | 881.6 | | |

[a] Totals may not add due to rounding.

TABLE 6-13

## TOTAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL[a] | TOTAL PER PLANT (DOLLARS) | TOTAL PER CAPITA (DOLLARS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,078 | 126,217 | 4.35 | 4.35 | 3.95 | 3.95 | 3.95 | 20.6 | 9,896 | 162.96 |
| 100-499 | 2,227 | 578,466 | 8.72 | 8.72 | 8.08 | 8.08 | 8.08 | 41.7 | 18,725 | 72.07 |
| 500-999 | 375 | 270,217 | 2.45 | 2.45 | 2.32 | 2.32 | 2.32 | 11.8 | 31,592 | 43.61 |
| 1,000-2,499 | 247 | 380,005 | 2.34 | 2.34 | 2.24 | 2.24 | 2.24 | 11.4 | 46,130 | 30.00 |
| 2,500-4,999 | 88 | 304,463 | 2.64 | 2.64 | 2.54 | 2.54 | 2.54 | 12.9 | 146,213 | 42.40 |
| 5,000-9,999 | 51 | 347,634 | 2.74 | 2.74 | 2.65 | 2.65 | 2.65 | 13.4 | 263,149 | 38.65 |
| 10,000-99,999 | 69 | 1,667,311 | 8.90 | 8.90 | 8.61 | 8.61 | 8.61 | 43.6 | 628,424 | 26.17 |
| 100,000-999,999 | 10 | 2,383,682 | 7.00 | 7.00 | 6.77 | 6.77 | 6.77 | 34.3 | 3,275,357 | 14.39 |
| >1,000,000 | | | | | | | | | | |
| TOTAL INVESTOR-OWNED COMMUNITY CAPITAL COSTS[a] | 5,146 | 6,056,219 | 39.14 | 39.14 | 37.16 | 37.16 | 37.16 | 189.8 | | |

[a] Totals may not add due to rounding.

TABLE 6-14

TOTAL ANNUAL CAPITAL EXPENDITURES BY SIZE OF SYSTEM
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL[a] | TOTAL PER PLANT (DOLLARS) | TOTAL PER CAPITA (DOLLARS) |
|---|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,756 | 167,397 | 5.77 | 5.77 | 5.25 | 5.25 | 5.25 | 27.3 | 9,898 | 162.96 |
| 100-499 | 5,072 | 1,317,695 | 19.66 | 19.66 | 18.42 | 18.42 | 18.42 | 95.0 | 18,725 | 72.07 |
| 500-999 | 1,561 | 1,140,158 | 10.32 | 10.32 | 9.77 | 9.77 | 9.77 | 49.9 | 31,592 | 43.81 |
| 1,000-2,499 | 1,460 | 2,275,479 | 14.02 | 14.02 | 13.41 | 13.41 | 13.41 | 66.3 | 46,130 | 30.00 |
| 2,500-4,999 | 712 | 2,455,510 | 21.30 | 21.30 | 20.50 | 20.50 | 20.50 | 104.1 | 146,213 | 42.40 |
| 5,000-9,999 | 444 | 3,022,906 | 23.85 | 23.85 | 23.05 | 23.05 | 23.05 | 116.6 | 263,149 | 38.65 |
| 10,000-99,999 | 609 | 14,625,537 | 76.07 | 76.07 | 75.52 | 75.52 | 75.52 | 382.7 | 628,424 | 26.17 |
| 100,000-999,999 | 56 | 12,748,032 | 37.44 | 37.44 | 36.18 | 36.18 | 36.18 | 183.4 | 3,275,357 | 14.39 |
| >1,000,000 | 2 | 5,010,781 | 8.80 | 8.80 | 8.80 | 8.80 | 8.80 | 44.0 | 22,000,000 | 8.78 |
| TOTAL COMMUNITY CAPITAL COSTS[a] | 12,712 | 42,763,495 | 219.43 | 219.43 | 210.90 | 210.90 | 210.90 | 1071.5 | | |

[a] Totals may not add due to rounding.

## TABLE 6-15

### TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 1,265 | 16,390,692 | 32.89 | 65.78 | 98.67 | 131.56 | 164.45 | 130,005 | 10.03 |
| CCE | 96 | 1,597,324 | .80 | 1.59 | 2.39 | 3.18 | 3.98 | 41,259 | 2.49 |
| $NO_3$ | 579 | 1,667,500 | 3.15 | 6.31 | 9.46 | 12.61 | 15.77 | 27,232 | 9.45 |
| CHLORINATION | 3,306 | 9,558,762 | 3.13 | 6.26 | 6.26 | 6.26 | 6.26 | 1,894 | .66 |
| MERCURY | 458 | 2,162,502 | 3.59 | 7.18 | 10.77 | 14.37 | 17.96 | 39,246 | 8.30 |
| SELENIUM | 227 | 604,464 | 1.27 | 2.54 | 3.80 | 5.07 | 6.34 | 27,966 | 10.49 |
| CADMIUM | 105 | 250,860 | .52 | 1.04 | 1.56 | 2.08 | 2.61 | 24,739 | 10.39 |
| LEAD | 407 | 1,330,435 | .02 | .04 | .07 | .09 | .11 | 270 | .08 |
| FLUORIDE | 933 | 2,689,518 | 1.76 | 3.52 | 5.27 | 7.03 | 8.79 | 9,423 | 3.27 |
| CHROMIUM | 80 | 188,145 | .41 | .82 | 1.24 | 1.65 | 2.06 | 25,661 | 10.96 |
| BARIUM | 28 | 62,712 | .15 | .30 | .45 | .60 | .75 | 26,660 | 11.69 |
| ARSENIC | 80 | 188,145 | .12 | .24 | .37 | .49 | .61 | 7,652 | 3.24 |
| TOTAL PUBLICLY-OWNED COMMUNITY O&M COSTS[a] | | | 47.81 | 95.63 | 140.31 | 185.00 | 229.68 | | |

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[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE 6-16

TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 861 | 2,712,679 | 4.82 | 9.65 | 14.47 | 19.29 | 24.12 | 28,011 | 8.89 |
| CCE | 66 | 264,359 | .12 | .23 | .35 | .47 | .58 | 8,690 | 2.21 |
| $NO_3$ | 394 | 275,973 | .46 | .92 | 1.39 | 1.85 | 2.31 | 5,867 | 8.36 |
| CHLORINATION | 2,251 | 1,581,969 | .46 | .92 | .92 | .92 | .92 | 408 | .58 |
| MERCURY | 311 | 357,697 | .53 | 1.05 | 1.58 | 2.11 | 2.63 | 8,456 | 7.36 |
| SELENIUM | 154 | 100,039 | .19 | .37 | .56 | .74 | .93 | 6,026 | 9.29 |
| CADMIUM | 72 | 41,516 | .08 | .15 | .23 | .31 | .38 | 5,330 | 9.20 |
| LEAD | 277 | 220,169 | .00 | .01 | .01 | .01 | .02 | 56 | .07 |
| FLUORIDE | 635 | 445,118 | .26 | .52 | .77 | 1.03 | 1.29 | 2,030 | 2.90 |
| CHROMIUM | 54 | 31,138 | .06 | .12 | .18 | .24 | .30 | 5,572 | 9.71 |
| BARIUM | 19 | 10,379 | .02 | .04 | .07 | .09 | .11 | 5,744 | 10.53 |
| ARSENIC | 54 | 31,138 | .02 | .04 | .05 | .07 | .09 | 1,649 | 2.87 |
| TOTAL INVESTOR-OWNED COMMUNITY O&M COSTS[a] | | | 7.01 | 14.02 | 20.58 | 27.13 | 33.66 | | |

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE 6-17

TOTAL ANNUAL O&M EXPENDITURES BY TREATMENT PROCESS
(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 2,126 | 19,103,371 | 37.71 | 75.43 | 113.14 | 150.86 | 188.57 | 88,697 | 9.87 |
| CCE | 162 | 1,861,663 | .91 | 1.82 | 2.74 | 3.65 | 4.56 | 28,149 | 2.45 |
| $NO_3$ | 973 | 1,943,473 | 3.62 | 7.23 | 10.85 | 14.46 | 18.08 | 18,580 | 9.30 |
| CHLORINATION | 5,557 | 11,140,771 | 3.59 | 7.18 | 7.18 | 7.18 | 7.18 | 1,292 | .64 |
| MERCURY | 769 | 2,520,399 | 4.12 | 8.24 | 12.35 | 16.47 | 20.59 | 26,776 | 8.17 |
| SELENIUM | 381 | 704,503 | 1.45 | 2.91 | 4.36 | 5.82 | 7.27 | 19,081 | 10.32 |
| CADMIUM | 177 | 292,378 | .60 | 1.19 | 1.79 | 2.39 | 2.99 | 16,879 | 10.22 |
| LEAD | 684 | 1,550,624 | .03 | .05 | .08 | .10 | .13 | 184 | .08 |
| FLUORIDE | 1,566 | 3,134,636 | 2.02 | 4.03 | 6.05 | 8.06 | 10.08 | 6,429 | 3.22 |
| CHROMIUM | 134 | 219,283 | .47 | .95 | 1.42 | 1.89 | 2.36 | 17,644 | 10.76 |
| BARIUM | 47 | 73,091 | .17 | .34 | .51 | .68 | .85 | 18,169 | 11.70 |
| ARSENIC | 134 | 219,283 | .14 | .28 | .42 | .56 | .70 | 5,221 | 3.19 |
| TOTAL COMMUNITY O&M COSTS[a] | | | 54.83 | 109.65 | 160.89 | 212.13 | 263.36 | | |

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

## TABLE 6-18

## TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 676 | 41,180 | .11 | .22 | .32 | .42 | .52 | 765 | 12.60 |
| 100-499 | 2,645 | 739,227 | .90 | 1.80 | 2.57 | 3.34 | 4.11 | 1,444 | 5.56 |
| 500-999 | 1,206 | 869,941 | .66 | 1.33 | 1.89 | 2.46 | 3.02 | 2,502 | 3.47 |
| 1,000-2,499 | 1,233 | 1,895,474 | 1.01 | 2.01 | 2.84 | 3.68 | 4.51 | 3,659 | 2.38 |
| 2,500-4,999 | 624 | 2,151,027 | 2.94 | 5.86 | 6.63 | 11.37 | 14.12 | 22,641 | 6.56 |
| 5,000-9,999 | 393 | 2,675,272 | 3.38 | 6.76 | 9.66 | 12.97 | 16.08 | 40,915 | 6.01 |
| 10,000-99,999 | 540 | 12,956,226 | 14.13 | 28.26 | 41.18 | 54.10 | 67.03 | 124,223 | 5.17 |
| 100,000-999,999 | 46 | 10,364,150 | 12.98 | 25.97 | 38.06 | 50.18 | 62.29 | 1,366,179 | 6.01 |
| >1,000,000 | 2 | 5,010,781 | 11.60 | 23.20 | 34.80 | 46.40 | 58.00 | 29,000,000 | 11.58 |
| TOTAL PUBLICLY-OWNED COMMUNITY O&M COSTS[a] | 7,566 | 36,705,277 | 47.71 | 95.43 | 140.18 | 184.93 | 229.66 | | |

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[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE 6-19

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,078 | 126,217 | .34 | .68 | .99 | 1.29 | 1.59 | 765 | 12.60 |
| 100-499 | 2,227 | 578,466 | .70 | 1.41 | 2.01 | 2.61 | 3.22 | 1,444 | 5.56 |
| 500-999 | 375 | 270,217 | .21 | .41 | .59 | .76 | .94 | 2,502 | 3.47 |
| 1,000-2,499 | 247 | 380,005 | .20 | .40 | .57 | .74 | .90 | 3,659 | 2.38 |
| 2,500-4,999 | 88 | 304,453 | .42 | .83 | 1.22 | 1.61 | 2.00 | 22,641 | 6.58 |
| 5,000-9,999 | 51 | 347,634 | .44 | .88 | 1.28 | 1.69 | 2.09 | 40,915 | 6.01 |
| 10,000-99,999 | 69 | 1,667,311 | 1.82 | 3.64 | 5.30 | 6.96 | 8.62 | 124,223 | 5.17 |
| 100,000-999,999 | 10 | 2,383,882 | 2.99 | 5.97 | 8.76 | 11.54 | 14.33 | 1,368,179 | 6.01 |
| >1,000,000 | | | | | | | | | |
| TOTAL INVESTOR-OWNED COMMUNITY O&M COSTS[a] | 5,146 | 6,058,219 | 7.11 | 14.23 | 20.71 | 27.20 | 33.69 | | |

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

TABLE 6-20

TOTAL ANNUAL O&M EXPENDITURES BY SIZE OF SYSTEM
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,756 | 167,397 | .45 | .91 | 1.31 | 1.71 | 2.11 | 765 | 12.60 |
| 100-499 | 5,072 | 1,317,695 | 1.60 | 3.21 | 4.56 | 5.95 | 7.33 | 1,444 | 5.56 |
| 500-999 | 1,561 | 1,140,158 | .67 | 1.74 | 2.48 | 3.22 | 3.96 | 2,502 | 3.47 |
| 1,000-2,499 | 1,480 | 2,275,479 | 1.21 | 2.42 | 3.42 | 4.42 | 5.42 | 3,659 | 2.36 |
| 2,500-4,999 | 712 | 2,455,510 | 3.36 | 6.71 | 9.65 | 12.98 | 16.12 | 22,641 | 6.56 |
| 5,000-9,999 | 444 | 3,022,906 | 3.62 | 7.63 | 11.14 | 14.66 | 18.17 | 40,915 | 6.01 |
| 10,000-99,999 | 609 | 14,625,537 | 15.95 | 31.69 | 46.46 | 61.07 | 75.65 | 124,223 | 5.17 |
| 100,000-999,999 | 56 | 12,748,032 | 15.97 | 31.94 | 46.63 | 61.73 | 76.62 | 1,368,179 | 6.01 |
| >1,000,000 | 2 | 5,010,781 | 11.60 | 23.20 | 34.60 | 46.40 | 58.00 | 29,000,000 | 11.56 |
| TOTAL COMMUNITY O&M COSTS[a] | 12,712 | 42,763,495 | 54.83 | 109.65 | 160.69 | 212.13 | 263.36 | | |

[a] Totals may not add due to rounding.

[b] Based on figures from 1983 when treatment is fully implemented.

for O&M expenses, while systems serving between 100,000 and one million people will pay an average of $5.84 per capita.

### 6.3.5 Total Annual Costs

The total annual costs are derived as the sum of the annual operation and maintenance costs, monitoring costs, and ownership costs. The annual ownership costs are based on an annual 11 percent debt service (principal plus interest), and a factor of 3 percent of capital costs to cover land amortization, insurance, taxes and other ownership costs.

The total annual costs for each treatment type are shown in Tables 6-21, 6-22, and 6-23, while the annual costs for each population served are shown in Tables 6-24, 6-25, and 6-26. These total annual costs are paid out each year for water treatment. The most expensive contaminants to treat, on a per capita basis, are barium, chromium, and selenium, with clarification being the most expensive on a per plant basis (Table 6-23).

The systems serving between 25 and 99 people pay an average of $34.78 per capita for treatment while the systems serving between 100,000 and one million people would pay $7.86 per capita per year for treatment. Systems serving over one million people pay $12.80 per capita per year because of the high percentage of plants needing clarification compared to other treatments.

TABLE 6-21

### TOTAL ANNUALIZED TOTAL COSTS[a] BY TREATMENT PROCESS FOR PUBLICLY-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 1,261 | 16,390,692 | 41.62 | 83.25 | 124.87 | 166.50 | 208.13 | 164,530 | 12.70 |
| CCE | 110 | 1,820,949 | 1.32 | 2.64 | 3.96 | 5.28 | 6.60 | 60,000 | 3.63 |
| $NO_3$ | 577 | 1,667,500 | 8.12 | 16.25 | 24.37 | 40.60 | 48.72 | 148,085 | 25.64 |
| CHLORINATION | 3,296 | 9,558,782 | 4.11 | 8.22 | 8.22 | 8.22 | 8.22 | 2,493 | 0.86 |
| MERCURY | 456 | 2,162,502 | 9.18 | 18.37 | 27.55 | 36.74 | 45.92 | 201,412 | 21.24 |
| SELENIUM | 226 | 604,464 | 3.26 | 6.51 | 9.77 | 13.03 | 16.28 | 144,097 | 26.96 |
| CADMIUM | 105 | 250,860 | 1.34 | 2.68 | 4.03 | 5.37 | 6.71 | 127,790 | 26.73 |
| LEAD | 406 | 1,330,435 | 0.08 | 0.17 | 0.25 | 0.33 | 0.42 | 2,044 | 0.31 |
| FLUORIDE | 930 | 2,689,518 | 2.41 | 4.82 | 7.24 | 9.65 | 12.06 | 25,940 | 4.48 |
| CHROMIUM | 79 | 188,145 | 1.06 | 2.12 | 3.18 | 4.24 | 5.30 | 134,127 | 28.18 |
| BARIUM | 28 | 62,712 | 0.38 | 0.77 | 1.15 | 1.54 | 1.92 | 137,071 | 30.95 |
| ARSENIC | 79 | 188,145 | 0.17 | 0.35 | 0.52 | 0.69 | 0.87 | 21,924 | 4.61 |
| SUBTOTAL PUBLICLY-OWNED COMMUNITY ANNUALIZED TOTAL COSTS[c] |  |  | 73.07 | 146.14 | 215.13 | 284.11 | 353.08 |  |  |
| MONITORING |  |  | 25.00 | 25.80 | 23.70 | 23.10 | 23.10 |  |  |
| TOTAL COMMUNITY[c] |  |  | 98.07 | 171.94 | 238.83 | 307.21 | 376.18 |  |  |

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-22

## TOTAL ANNUALIZED TOTAL COSTS[a] BY TREATMENT PROCESS FOR INVESTOR-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATION | 865 | 2,712,679 | 6.71 | 13.41 | 20.12 | 26.82 | 33.54 | 38,769 | 12.37 |
| CCE | 75 | 301,369 | 0.28 | 0.46 | 0.70 | 0.93 | 1.16 | 15,446 | 3.85 |
| $NO_3$ | 396 | 275,973 | 1.53 | 3.07 | 4.60 | 6.14 | 7.67 | 19,366 | 27.79 |
| CHLORINATION | 2,261 | 1,581,989 | 0.67 | 1.35 | 1.35 | 1.35 | 1.35 | 597 | 0.85 |
| MERCURY | 313 | 357,897 | 1.74 | 3.48 | 5.21 | 6.95 | 8.69 | 36,761 | 24.28 |
| SELENIUM | 155 | 100,039 | 0.62 | 1.24 | 1.86 | 2.48 | 3.10 | 19,993 | 30.99 |
| CADMIUM | 72 | 41,518 | 0.26 | 0.52 | 0.77 | 1.03 | 1.29 | 17,902 | 31.43 |
| LEAD | 278 | 220,189 | 0.01 | 0.02 | 0.03 | 0.04 | 0.06 | 216 | 0.27 |
| FLUORIDE | 638 | 445,118 | 0.40 | 0.80 | 1.20 | 1.61 | 2.01 | 3,146 | 4.51 |
| CHROMIUM | 55 | 31,138 | 0.20 | 0.40 | 0.60 | 0.80 | 1.00 | 18,182 | 32.25 |
| BARIUM | 19 | 10,379 | 0.07 | 0.14 | 0.21 | 0.28 | 0.35 | 18,526 | 35.20 |
| ARSENIC | 55 | 31,138 | 0.03 | 0.06 | 0.09 | 0.12 | 0.16 | 2,836 | 5.03 |
| SUBTOTAL INVESTOR-OWNED COMMUNITY ANNUALIZED TOTAL COSTS[c] | | | 12.47 | 24.95 | 36.74 | 48.55 | 60.38 | | |
| MONITORING | | | 7.90 | 8.20 | 6.50 | 7.30 | 7.30 | | |
| TOTAL COMMUNITY[c] | | | 20.37 | 33.15 | 43.24 | 55.85 | 67.68 | | |

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-23

TOTAL ANNUALIZED TOTAL COSTS BY TREATMENT PROCESS[a]
(Millions of Dollars Unless Otherwise Noted)

| PROCESS | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| CLARIFICATIONN | 2,126 | 19,103,371 | 48.33 | 96.66 | 145.00 | 193.33 | 241.66 | 113,668 | 12.65 |
| CCE | 185 | 2,122,319 | 1.54 | 3.08 | 4.62 | 6.16 | 7.70 | 41,622 | 3.63 |
| $NO_3$ | 973 | 1,943,473 | 9.67 | 19.33 | 29.00 | 38.66 | 48.33 | 49,667 | 24.87 |
| CHLORINATION | 5,557 | 11,140,771 | 4.78 | 9.57 | 9.57 | 9.57 | 9.57 | 1,722 | 0.86 |
| MERCURY | 769 | 2,520,399 | 10.92 | 21.84 | 32.77 | 43.69 | 54.61 | 71,009 | 21.84 |
| SELENIUM | 381 | 704,503 | 3.87 | 7.73 | 11.60 | 15.47 | 19.33 | 50,740 | 27.47 |
| CADMIUM | 177 | 292,378 | 1.60 | 3.20 | 4.80 | 6.40 | 8.00 | 45,186 | 27.39 |
| LEAD | 684 | 1,550,624 | 0.11 | 0.21 | 0.32 | 0.43 | 0.54 | 782 | 0.34 |
| FLUORIDE | 1,568 | 3,134,636 | 2.81 | 5.62 | 8.44 | 11.25 | 14.07 | 8,972 | 4.48 |
| CHROMIUM | 134 | 219,283 | 1.26 | 2.52 | 3.78 | 5.04 | 6.30 | 47,135 | 28.80 |
| BARIUM | 47 | 73,091 | 0.45 | 0.91 | 1.36 | 1.82 | 2.27 | 48,319 | 31.10 |
| ARSENIC | 134 | 219,283 | 0.20 | 0.41 | 0.61 | 0.82 | 1.02 | 7,627 | 4.67 |
| SUBTOTAL COMMUNITY O&M COSTS AND CAPITAL COSTS[c] | | | 85.55 | 171.08 | 251.87 | 332.64 | 413.40 | | |
| MONITORING | | | 32.90 | 34.00 | 31.20 | 30.40 | 30.40 | | |
| SUBTOTAL COMMUNITY[c] | | | 118.45 | 205.08 | 283.07 | 363.04 | 443.80 | | |
| SUBTOTAL NON-COMMUNITY[c] | | | 108.70 | 109.80 | 107.00 | 106.20 | 99.90 | | |
| TOTAL[c] | | | 227.15 | 314.88 | 390.07 | 469.24 | 543.70 | | |

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-24

TOTAL ANNUALIZED TOTAL COSTS[a] BY SIZE OF SYSTEM FOR PUBLICLY-OWNED UTILITIES
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 678 | 41,180 | 0.31 | 0.62 | 0.90 | 1.18 | 1.46 | 2,153 | 35.45 |
| 100-499 | 2,845 | 739,227 | 2.46 | 4.92 | 7.14 | 9.36 | 11.58 | 4,070 | 15.67 |
| 500-999 | 1,206 | 869,941 | 1.76 | 3.52 | 5.14 | 6.76 | 8.38 | 6,948 | 9.64 |
| 1,000-2,499 | 1,233 | 1,895,474 | 2.65 | 5.29 | 7.67 | 10.05 | 12.43 | 10,081 | 4.42 |
| 2,500-4,999 | 624 | 2,151,027 | 5.55 | 11.10 | 16.37 | 21.64 | 26.91 | 43,119 | 12.51 |
| 5,000-9,999 | 393 | 2,675,272 | 6.33 | 12.66 | 18.62 | 24.58 | 30.54 | 77,720 | 11.42 |
| 10,000-99,999 | 540 | 12,958,226 | 23.81 | 47.63 | 69.92 | 92.21 | 114.40 | 211,842 | 8.83 |
| 100,000-999,999 | 46 | 10,364,150 | 17.24 | 34.48 | 50.72 | 66.96 | 83.21 | 1,808,913 | 8.03 |
| >1,000,000 | 2 | 5,010,781 | 12.83 | 25.66 | 39.50 | 51.33 | 64.16 | 32,080,000 | 12.81 |
| SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c] | | | 72.95 | 145.88 | 214.98 | 284.07 | 353.07 | | |
| MONITORING | | | 25.00 | 25.80 | 23.70 | 23.10 | 23.10 | | |
| TOTAL COMMUNITY[c] | | | 97.95 | 171.68 | 238.68 | 307.17 | 376.17 | | |

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

TABLE 6-25

## TOTAL ANNUALIZED TOTAL COSTS[a] BY SIZE OF SYSTEM FOR INVESTOR-OWNED UTILITIES

(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,078 | 126,217 | 0.95 | 1.90 | 2.76 | 3.62 | 4.48 | 2,153 | 35.55 |
| 100-499 | 2,227 | 578,468 | 1.92 | 3.84 | 5.60 | 7.36 | 9.12 | 4,070 | 15.67 |
| 500-999 | 375 | 270,217 | 0.55 | 1.10 | 1.60 | 2.10 | 2.59 | 6,948 | 9.64 |
| 1,000-2,499 | 247 | 380,005 | 0.53 | 1.06 | 1.54 | 2.02 | 2.50 | 10,081 | 4.42 |
| 2,500-4,999 | 88 | 304,483 | 0.79 | 1.58 | 2.54 | 3.50 | 4.52 | 43,119 | 12.51 |
| 5,000-9,999 | 51 | 347,634 | 0.82 | 1.64 | 2.42 | 3.20 | 3.97 | 77,720 | 11.42 |
| 10,000-99,999 | 69 | 1,667,311 | 3.07 | 6.14 | 9.00 | 11.86 | 14.72 | 211,842 | 8.83 |
| 100,000-999,999 | 10 | 2,383,882 | 3.97 | 7.94 | 11.67 | 15.40 | 19.13 | 1,808,913 | 8.03 |
| >1,000,000 | | | | | | | | | |
| SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c] | | | 12.59 | 25.20 | 37.13 | 49.06 | 61.03 | | |
| MONITORING | | | 7.90 | 8.20 | 6.50 | 7.30 | 7.30 | | |
| TOTAL COMMUNITY[c] | | | 20.49 | 33.40 | 43.63 | 56.36 | 67.33 | | |

---

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

## TABLE 6-26

## TOTAL ANNUALIZED TOTAL COSTS BY SIZE OF SYSTEM[a]
(Millions of Dollars Unless Otherwise Noted)

| POPULATION SIZE CATEGORY | TOTAL # OF PLANTS | TOTAL POPULATION AFFECTED | 1979 | 1980 | 1981 | 1982 | 1983 | TOTAL PER PLANT (DOLLARS)[b] | TOTAL PER CAPITA (DOLLARS)[b] |
|---|---|---|---|---|---|---|---|---|---|
| 25-99 | 2,756 | 167,397 | 1.26 | 2.52 | 3.66 | 4.80 | 5.94 | 2,153 | 35.55 |
| 100-499 | 5,072 | 1,317,695 | 4.38 | 8.76 | 12.72 | 16.68 | 20.64 | 4,070 | 15.67 |
| 500-999 | 1,581 | 1,140,158 | 2.31 | 4.62 | 6.74 | 8.86 | 10.98 | 6,948 | 9.64 |
| 1,000-2,499 | 1,480 | 2,275,479 | 3.17 | 6.34 | 9.22 | 12.10 | 14.98 | 10,081 | 4.42 |
| 2,500-4,999 | 712 | 2,455,510 | 6.34 | 12.68 | 18.68 | 24.68 | 30.69 | 43,119 | 12.51 |
| 5,000-9,999 | 444 | 3,022,906 | 7.16 | 14.32 | 21.04 | 27.76 | 34.52 | 77,720 | 11.42 |
| 10,000-99,999 | 609 | 14,625,537 | 26.88 | 53.76 | 78.91 | 104.06 | 129.23 | 211,842 | 8.83 |
| 100,000-999,999 | 56 | 12,748,032 | 21.21 | 42.42 | 62.38 | 83.34 | 104.30 | 1,808,913 | 8.03 |
| >1,000,000 | 2 | 5,010,781 | 12.83 | 25.66 | 38.50 | 51.33 | 64.16 | 32,080,000 | 12.81 |
| SUBTOTAL COMMUNITY O&M COSTS AND ANNUALIZED CAPITAL COSTS[c] | | | 85.55 | 171.08 | 251.85 | 333.61 | 415.44 | | |
| MONITORING | | | 32.90 | 34.00 | 31.20 | 30.40 | 30.40 | | |
| SUBTOTAL COMMUNITY[c] | | | 118.45 | 205.08 | 283.05 | 364.01 | 445.84 | | |
| SUBTOTAL NON-COMMUNITY[c] | | | 108.70 | 109.80 | 107.00 | 106.20 | 106.20 | | |
| TOTAL[c] | | | 227.15 | 314.88 | 390.05 | 470.21 | 552.04 | | |

[a] Assumes: (1) Debt service of 11 percent/year on capital; (2) Capital ownership cost of 3 percent to cover taxes, insurance, etc.; (3) Annual O&M costs.

[b] Based on figures from 1983 when treatment is fully implemented.

[c] Table may not add due to rounding.

## CHAPTER SEVEN

## ECONOMIC IMPACT ANALYSIS

### 7.0 Introduction

The previous six chapters developed the aggregate costs of implementing the Proposed Interim Primary Drinking Water Regulations. This chapter examines the impact of the regulations on the individual consumer, and it explores the economic impact on all three classes of water users. In developing the treatment costs it has been assumed that installation of treatment facilities will be the option chosen by the community systems to meet the interim regulations. There are several other options available to these systems, including purchase of water from existing systems, development of alternative sources, regionalization of systems, and possible use of exemptions and variances until solutions to the on-site problems can be found. It is possible that these alternatives may be less expensive, especially for small systems, and they should be examined on a site-by-site basis.

### 7.1 Monitoring Impacts

The number of samples required per person, as a function of the size of a given system, must first be determined. This is not difficult for chemical monitoring since under ordinary circumstances the required sampling frequency per system depends only on the system type (groundwater vs. surface-water; community vs. other) and not on the number of people served. The requirements for public systems are summarized in Table 7-1. Thus, for example, a 32-person groundwater system must perform 0.015 (0.5 analyses ÷ 32 people) chemical analyses per person per year in the first two years after implementation of the regulations, and 0.0100 (0.33 analyses ÷ 32 people) chemical analyses per person per year thereafter. A surface water system serving one million people must perform $10^{-6}$ (1 analysis ÷ 1,000,000 people) chemical analysis per person per year.

In the case of ordinary bacteriological monitoring the sampling requirements of the interim primary regulations are more complex. Two coliform samples per month are required

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## TABLE 7-1

## CHEMICAL SAMPLING REQUIREMENTS FOR PUBLIC WATER SYSTEMS

| TYPE OF SYSTEM | COMPLIANCE TIME FOR INITIAL ANALYSIS (NUMBER OF YEARS) | TIME INTERVAL FOR SUBSEQUENT ANALYSES (NUMBER OF YEARS) |
|---|---|---|
| Community - surface-water | 1 | 1 |
| Community - groundwater | 2 | 3 |
| Other - surface | 6 | 5 |

of systems serving under 2,500 people, while two monthly samples for each 1,000 people are required for systems serving between 2,500 and 100,000 people. The required rate per person falls off for larger systems; e.g., 200 samples per month for a 100,000 person system and 500 samples per month for systems serving 5,000,000 or more people. Plate counts must be taken once monthly (minimum) or at 10 percent the rate of coliform samples, whichever is greater.

Since the required number of plate count analyses is a function of coliform sampling requirements, the numbers of both analyses can be added as a step in determining costs. This has been done in the construction of Figure 7-1, which plots the number of bacteriological samples (coliform plus plate count) required per person per year against the size of the water system.

The monitoring costs per person developed for systems of representative sizes are shown in Table 7-2.

The figures for bacteriological samples are taken from Figure 7-1. Costs per analysis are calculated assuming a cost of $7.50 per bacteriological analysis and $400.00 for complete organic and inorganic chemical analyses (these are the median monitoring costs developed in Chapter Four). Thus the maximum cost would be $26.80 per person per year in a surface water system serving 25 people. Costs per person per year are plotted in Figures 7-2 and 7-3.

## 7.2 Price Impacts - Case Studies of Model Systems

The additional treatment necessitated by the Proposed Interim Primary Drinking Water Regulations would result in additional treatment costs for water supply systems, costs which in turn would be passed on to water customers in the form of higher rates. In order to demonstrate the impact of additional treatment costs on water rates, model systems of three sizes, based on population served, are analyzed.

To simplify the analysis of the aggregate impact under the interim primary regulations, an interest rate of 7 percent has been designated as the cost of financing for an average water system. A second simplifying assumption was that a 15-year payoff period would be used to finance the costs. As mentioned earlier, small investor-owned facilities are riskier than large government-owned operations. The cost of money to the former is correspondingly higher than to the latter. Tables 7-3, 7-4, and 7-5 break down the per capita

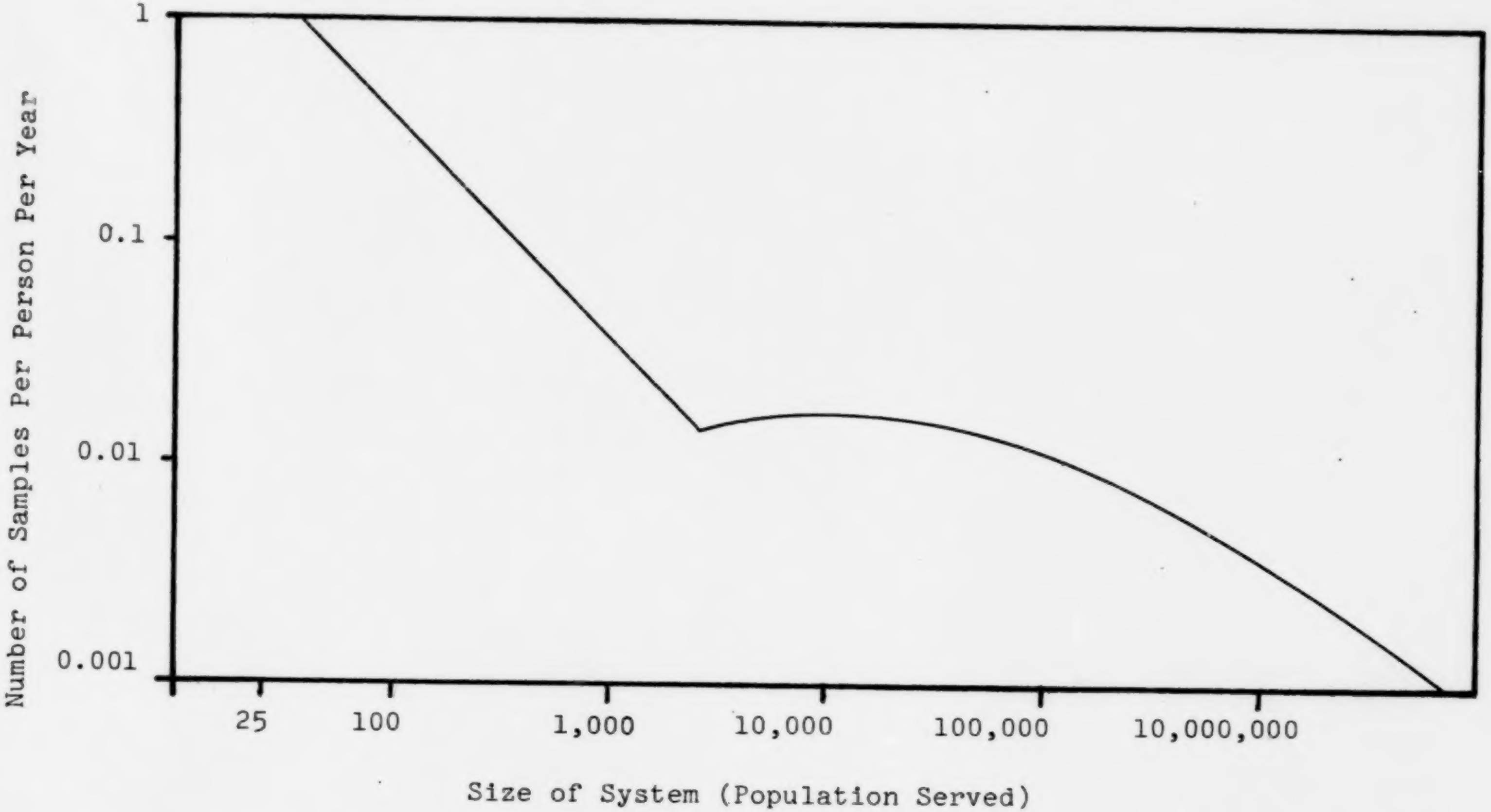

Figure 7-1. This figure displays the annual per capita bacteriological samples versus size of water system.

### TABLE 7-2

### ANALYTICAL COSTS PER PERSON VERSUS SYSTEM SIZE AND TYPE FOR COMMUNITY WATER SYSTEMS

| System Size | Samples Per Person Per Year | | | Analysis Costs Per Person Per Year ($) | | | | |
|---|---|---|---|---|---|---|---|---|
| | Bacteriological | Chemical[a] | Chemical[b] | Bacteriological[c] | Chemical[a,d] | Chemical[b,d] | Total[a] | Total[b] |
| 32 | 1.13 | 0.032 | 0.010 | 8.47 | 12.80 | 4.00 | 21.27 | 12.47 |
| 100 | 0.360 | 0.010 | 0.0032 | 2.70 | 4.00 | 1.28 | 6.70 | 3.98 |
| 320 | 0.115 | 0.0032 | 0.0010 | 0.86 | 1.28 | 0.40 | 2.14 | 1.26 |
| 1,000 | 0.0360 | 0.0010 | 0.00032 | 0.27 | 0.40 | 0.13 | 0.67 | 0.40 |
| 3,200 | 0.0154 | 0.00032 | 0.00010 | 0.11 | 0.13 | 0.04 | 0.24 | 0.15 |
| 10,000 | 0.0168 | 0.00010 | 0.000032 | 0.13 | 0.04 | 0.01 | 0.17 | 0.14 |
| 32,000 | 0.0150 | 0.000032 | 0.000010 | 0.11 | 0.01 | 0.005 | 0.12 | 0.12 |
| 100,000 | 0.0132 | 0.000010 | 0.0000032 | 0.10 | 0.005 | 0.001 | 0.11 | 0.10 |
| 320,000 | 0.0072 | 0.0000032 | 0.0000010 | 0.05 | 0.001 | 0 | 0.05 | 0.05 |
| 1,000,000 | 0.00396 | 0.0000010 | 0.00000032 | 0.03 | 0 | 0 | 0.03 | 0.03 |
| 3,200,000 | 0.00190 | 0.00000032 | 0.00000010 | 0.01 | 0 | 0 | 0.01 | 0.01 |
| 10,000,000 | 0.00066 | 0.00000010 | 0.000000032 | 0.005 | 0 | 0 | 0.005 | 0.005 |

[a] For Surface System: rate - one chemical sample per year.

[b] For Ground System: rate - one chemical sample each 3 years.

[c] Estimated Cost: $7.50 per analysis.

[d] Estimated Cost: $400 per analysis

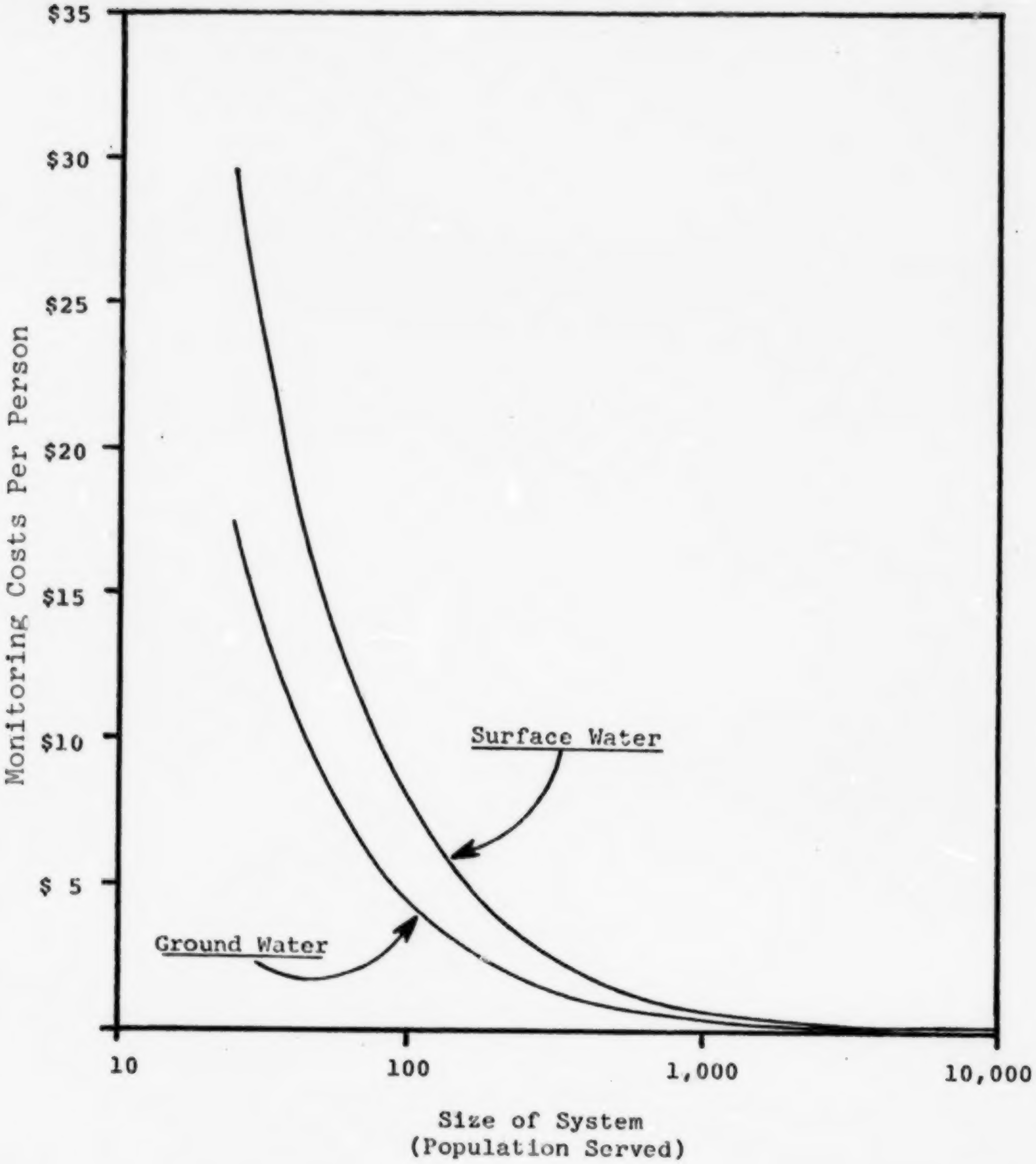

Figure 7-2. This figure shows annual monitoring costs per person - small system.

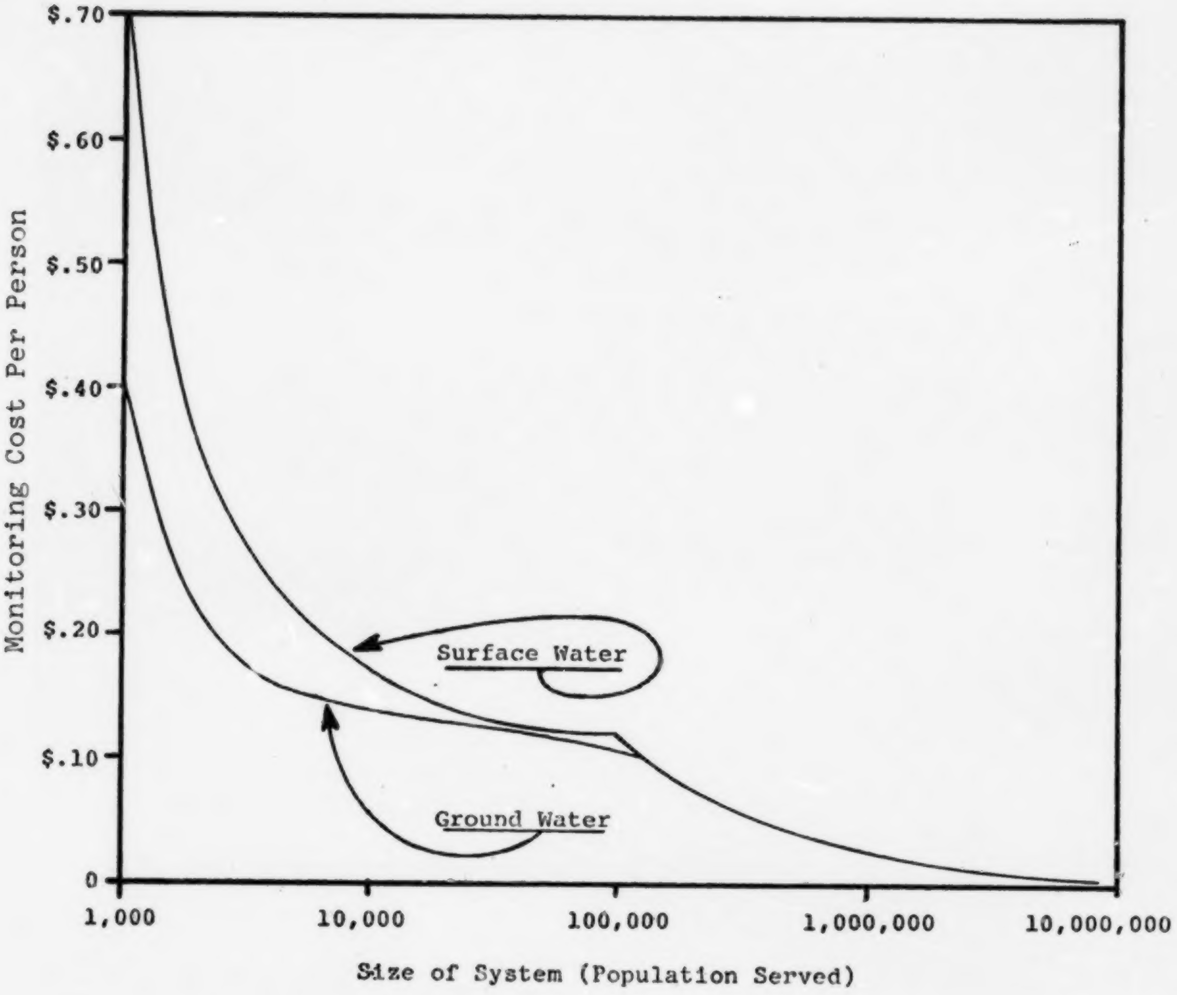

Figure 7-3. This figure shows annual monitoring costs per person - large system.

impacts of these different financing costs according to utility size and treatment process. Measured only against the costs of new plant and equipment, financing charges and pay back period differences are not insignificant (Tables 7-3, 7-4, and 7-5) when all costs are considered, however, the per capita impact of different interest rates is less noticeable (Table 7-6).

The annual cost of each of six potential treatments was computed for each model system. Table 7-7 shows that unit costs range from $0.003 per thousand gallons for pH control in a large system to $2.27 per thousand gallons for ion exchange in a small system.

While the combination of treatments required depends on the composition of the impurities requiring treatment, a probability analysis showed that no more than two types of treatment would be used within a single system. The most common required treatment combinations are listed in Table 7-8, along with the projected percentage of occurrence by system size.

Note that clarification alone accounts for nearly two-thirds of all surface-water treatment in the smaller regulation category. Chlorination alone and ion exchange alone are the most frequently needed treatments for ground-water systems.

Costs for each treatment are developed in Tables 7-7 and 7-9. Ion exchange is generally one order of magnitude more expensive than chlorination and systems serving 100 people are by far the most expensive to treat on a per capita basis (Table 7-9). Although ion exchange is the most expensive treatment for all sizes of systems, clarification costs are also significant.

According to the National Association of Water Companies,[1] total revenue from water sales is segregated as follows: 61 percent residential, 19 percent commercial, 8 percent industrial, 11 percent other (mainly municipalities and other agencies) (Table 7-10).

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[1] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities" (Washington, D.C.), p. 2.

## TABLE 7-3

## PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 100 PEOPLE[a]

| PROCESS | CAPITAL COST ($)[b] | INTEREST RATE[c] | ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS | ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS |
|---|---|---|---|---|---|---|---|---|
| Chlorination | 810 | 11 | 138 | 121 | 119 | 1.38 | 1.21 | 1.19 |
| | | 9 | 121 | 113 | 105 | 1.21 | 1.13 | 1.05 |
| | | 7 | 113 | 97 | 93 | 1.13 | 0.97 | 0.93 |
| Clarification | 23,500 | 11 | 3,910 | 3,687 | 3,471 | 39.10 | 36.87 | 34.71 |
| | | 9 | 3,567 | 3,243 | 3,074 | 35.67 | 32.43 | 30.74 |
| | | 7 | 3,241 | 2,890 | 2,700 | 32.41 | 28.90 | 27.00 |
| Ion Exchange | 48,000 | 11 | 7,987 | 7,387 | 7,090 | 79.87 | 73.87 | 70.90 |
| | | 9 | 7,286 | 6,624 | 6,278 | 72.86 | 66.24 | 62.78 |
| | | 7 | 6,619 | 5,904 | 5,515 | 66.19 | 59.04 | 55.15 |
| Activated Alumina | 3,400 | 11 | 566 | 523 | 502 | 5.66 | 5.23 | 5.02 |
| | | 9 | 516 | 469 | 445 | 5.16 | 4.69 | 4.45 |
| | | 7 | 469 | 419 | 391 | 4.69 | 4.19 | 3.91 |
| Activated Carbon | 2,100 | 11 | 349 | 323 | 310 | 3.49 | 3.23 | 3.10 |
| | | 9 | 319 | 290 | 275 | 3.19 | 2.90 | 2.75 |
| | | 7 | 290 | 259 | 241 | 2.90 | 2.59 | 2.41 |

---

[a] Assumes only residential use.

[b] Based on 109 gallons (0.412 $m^3$) produced per consumer per day.

[c] Does not include 3 percent for insurance, taxes, etc.

TABLE 7-4

## PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 5,000 PEOPLE[a]

| PROCESS | CAPITAL[b] COST ($) | INTEREST[c] RATE | ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS | ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS |
|---|---|---|---|---|---|---|---|---|
| Chlorination | 10,000 | 9 | 1,518 | 1,379 | 1,313 | 0.30 | 0.27 | 0.26 |
| | | 7 | 1,380 | 1,231 | 1,160 | 0.28 | 0.25 | 0.23 |
| | | 6 | 1,308 | 1,149 | 1,074 | 0.26 | 0.23 | 0.21 |
| Clarification | 220,000 | 9 | 33,396 | 30,360 | 28,776 | 6.68 | 6.08 | 5.75 |
| | | 7 | 30,338 | 27,060 | 25,278 | 6.08 | 5.41 | 5.06 |
| | | 6 | 28,886 | 25,520 | 23,628 | 5.78 | 5.10 | 4.73 |
| Ion Exchange | 660,000 | 9 | 100,188 | 91,030 | 86,328 | 20.04 | 18.20 | 17.27 |
| | | 7 | 91,014 | 81,180 | 75,834 | 18.20 | 16.24 | 15.17 |
| | | 6 | 86,658 | 76,560 | 70,884 | 17.33 | 15.31 | 14.18 |
| Activated Alumina | 50,000 | 9 | 7,590 | 6,900 | 6,540 | 1.52 | 1.38 | 1.31 |
| | | 7 | 6,895 | 6,155 | 5,745 | 1.38 | 1.23 | 1.15 |
| | | 6 | 6,565 | 5,850 | 5,370 | 1.31 | 1.16 | 1.07 |
| Activated Carbon | 93,000 | 9 | 14,117 | 12,834 | 12,164 | 2.82 | 2.56 | 2.43 |
| | | 7 | 12,825 | 11,448 | 10,686 | 2.56 | 2.29 | 2.14 |
| | | 6 | 12,211 | 10,788 | 9,988 | 2.44 | 2.16 | 2.00 |

[a] Assumes only residential use.

[b] Based on 154 gallons (0.582 $m^3$) produced per consumer per day.

[c] Does not include 3 percent for insurance, taxes, etc.

## TABLE 7-5

## PER CAPITA ANNUALIZED CAPITAL COSTS FOR A SYSTEM SERVING 100,000 PEOPLE[a]

| PROCESS | CAPITAL[b] COST ($) | INTEREST[c] RATE | ANNUAL CAPITAL COSTS ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS | ANNUAL CAPITAL COST PER CAPITA ($) PAY BACK PERIOD 15 YRS | 20 YRS | 25 YRS |
|---|---|---|---|---|---|---|---|---|
| Chlorination | 100,000 | 9 | 15,180 | 13,790 | 13,130 | 0.15 | 0.14 | 0.13 |
| | | 7 | 13,800 | 12,310 | 11,600 | 0.14 | 0.12 | 0.12 |
| | | 6 | 10,080 | 8,490 | 7,740 | 0.10 | 0.08 | 0.08 |
| Clarification | 1,900,000 | 9 | 288,420 | 262,200 | 248,520 | 2.88 | 2.62 | 2.49 |
| | | 7 | 262,010 | 233,890 | 218,310 | 2.62 | 2.34 | 2.18 |
| | | 6 | 249,470 | 220,400 | 204,060 | 2.49 | 2.20 | 2.04 |
| Ion Exchange | 5,800,000 | 9 | 880,440 | 880,400 | 758,640 | 8.80 | 8.00 | 7.59 |
| | | 7 | 799,820 | 713,980 | 666,420 | 8.00 | 7.14 | 6.66 |
| | | 6 | 761,540 | 672,800 | 622,920 | 7.61 | 6.72 | 6.23 |
| Activated Alumina | 350,000 | 9 | 53,130 | 48,300 | 45,780 | 0.53 | 0.48 | 0.46 |
| | | 7 | 48,265 | 43,085 | 40,615 | 0.48 | 0.43 | 0.40 |
| | | 6 | 45,955 | 40,600 | 37,590 | 0.46 | 0.41 | 0.38 |
| Activated Carbon | 1,100,000 | 9 | 166,980 | 151,800 | 143,880 | 1.67 | 1.52 | 1.44 |
| | | 7 | 151,690 | 135,410 | 126,390 | 1.52 | 1.35 | 1.26 |
| | | 6 | 144,430 | 127,600 | 118,140 | 1.44 | 1.27 | 1.18 |

[a] Assumes only residential use.

[b] Based on 174 gallons (0.658 $m^3$) produced per consumer per day.

[c] Does not include 3 percent for insurance, taxes, etc.

TABLE 7-6

## DISTRIBUTION OF COSTS FOR THOSE SYSTEMS NEEDING TREATMENT BY SIZE OF SYSTEM FOR FOUR SIZE RANGES

|  | SMALLEST SYSTEMS (25-99 PEOPLE SERVED) | SMALL SYSTEMS (100-9,999 (PEOPLE SERVED) | MEDIUM SYSTEMS (10,000-99,999 (PEOPLE SERVED) | LARGE SYSTEMS (OVER 100,000 PEOPLE SERVED) |
|---|---|---|---|---|
| Annual Capital Costs ($ million) | 3.8 - 6.4 | 60.8 - 102.1 | 53.6 - 90.0 | 31.8 - 53.4 |
| Annual O&M Costs ($ million) | 2.1 |  |  |  |
| Annual Monitoring Costs ($ million) | 0.5 - 1.0 | 0.9 - 1.8 | 1.8 - 3.8 | 1.9 - 4.2 |
| TOTAL ANNUAL COSTS ($ million) | 6.4 - 9.5 | 112.7 - 154.9 | 131.1 - 169.5 | 168.3 - 192.2 |
| Average Cost per Capita per year ($) | 38 - 56 | 11 - 15 | 9 - 12 | 10 - 11 |
| Increase in Household Monthly Water Bill[a] | 9.93 - 14.74 | 2.86 - 3.93 | 2.32 - 3.01 | 2.46 - 2.91 |

[a] Assumes 3.11 persons per household and that all increases in costs are passed on to the consumer.

TABLE 7-7

## ANNUALIZED COSTS[a] OF TREATMENT IN MODEL SYSTEMS
(Dollars per 1,000 Gallons)

| | SYSTEM SIZE (POPULATION SERVED) | | | | | |
|---|---|---|---|---|---|---|
| | 100[b] | | 5,000[c] | | 100,000[d] | |
| PROCESS | TOTAL ($) | COST ($) | TOTAL ($) | COST ($) | TOTAL ($) | COST ($) |
| Chlorination | 209 | 0.05 | 8,880 | 0.03 | 183,800 | 0.03 |
| Clarification | 5,251 | 1.32 | 84,338 | 0.30 | 1,262,010 | 0.20 |
| Ion Exchange | 9,019 | 2.27 | 154,014 | 0.55 | 1,299,820 | 0.20 |
| Activated Alumina | 779 | 0.19 | 22,895 | 0.08 | 318,265 | 0.05 |
| Activated Carbon | 4,690 | 1.18 | 54,825 | 0.19 | 243,690 | 0.04 |
| pH Control | 61 | 0.02 | 1,730 | 0.006 | 21,700 | 0.003 |

[a] Assumes 7 percent annual interest on capital costs amortized over 15 years, plus O&M.

[b] Assumes 109 gallons (0.412 $m^3$) per capita day production.

[c] Assumes 154 gallons (0.582 $m^3$) per capita day production.

[d] Assumes 174 gallons (0.658 $m^3$) per capita day production.

## TABLE 7-8

## PROBABILITY OF NEEDING TREATMENT COMBINATIONS BY SYSTEM SIZE
(Percent of Systems)

| PROCESS | System Size (Population Served) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 25 - 99 | | 100 - 9,999 | | 10,000 - 99,999 | | Over 100,000 | |
| | SURFACE | GROUND | SURFACE | GROUND | SURFACE | GROUND | SURFACE | GROUND |
| No Treatment | 1 | 66 | 18 | 74 | 28 | 79 | 69 | 81 |
| Chlorination Only | | 19 | 2 | 12 | 2 | 6 | 4 | 4 |
| Clarification Only | 72 | | 65 | | 59 | | 20 | |
| Ion Exchange Only | | 5 | | 6 | 1 | 6 | 2 | 7 |
| pH Control Only | | 1 | | 2 | | 2 | | 2 |
| Activated Alumina Only | | 4 | | 4 | | 5 | | 5 |
| Activated Carbon Only | | 1 | | | 1 | | 2 | |
| Chlorination & Ion Exchange | 2 | 2 | | 1 | 2 | 1 | | |
| Chlorination & Activated Alumina | | 1 | | 1 | | | | |
| Chlorination & Clarification | 21 | | 9 | | 5 | | 1 | |
| Chlorination & Activated Carbon | 3 | | 2 | | 2 | | 1 | |
| Clarification & Ion Exchange | | | 2 | | | | 1 | |

## TABLE 7-9

## PROJECTED COSTS[a] EFFECTS BY TREATMENT PROCESS ON THREE SIZED WATER SYSTEMS

| PROCESS | 100 PEOPLE[b] | | | 5,000 PEOPLE[c] | | | 100,000 PEOPLE[d] | | |
|---|---|---|---|---|---|---|---|---|---|
| | $/1,000 GAL | $/CAPITA | $/HOUSEHOLD | $/1,000 GAL | $/CAPITA | $/HOUSEHOLD | $/1,000 GAL | $/CAPITA | $/HOUSEHOLD |
| Chlorination | 0.05 | 2.16 | 6.72 | 0.03 | 1.78 | 5.52 | 0.03 | 1.79 | 5.72 |
| Clarification | 1.32 | 52.51 | 163.31 | 0.30 | 16.87 | 52.46 | 0.20 | 12.62 | 39.25 |
| Ion Exchange | 2.27 | 90.19 | 280.49 | 0.55 | 30.80 | 95.80 | 0.20 | 13.00 | 40.43 |
| Activated Alumina | 0.19 | 7.79 | 24.23 | 0.08 | 4.58 | 14.24 | 0.05 | 3.18 | 9.89 |
| Activated Carbon | 1.18 | 46.90 | 145.86 | 0.19 | 10.97 | 34.10 | 0.04 | 2.44 | 7.59 |
| pH Control | 0.02 | 0.61 | 1.87 | 0.006 | 0.35 | 1.08 | 0.003 | 0.02 | 0.07 |

[a] Assumes 7 percent interest on capital costs amortized over 15 years plus O&M costs.

[b] Assumes 109 gallons (0.412 $m^3$) produced per person per day.

[c] Assumes 154 gallons (0.582 $m^3$) produced per person per day.

[d] Assumes 174 gallons (0.658 $m^3$) produced per person per day.

## TABLE 7-10

## WATER SALES AND REVENUE BY TYPE OF CUSTOMER[a]

| TYPE OF CONSUMER | PERCENT OF TOTAL USE | PERCENT OF TOTAL REVENUE |
|---|---|---|
| Residential | 44 | 61 |
| Commercial | 27 | 19 |
| Industrial | 19 | 8 |
| Other | 10 | 11 |
| PERCENT OF TOTAL | 100 | 99 |

[a] National Association of Water Companies, "1973 Financial Summary for Investor-Owned Water Utilities."

If the present distribution of costs continues, the additional costs of chlorination and clarification -- the most frequent treatment processes -- will fall according to the pattern displayed in Table 7-11. Should rates align with usage, then all users in a particular system would pay the same rate (e.g., 15.5 cents per 1,000 gallons would be the price increase for residential, commercial, industrial, and other users in the 100-person chlorination only system).

Assuming that the current average price for water is $0.60 per 1,000 gallons, the smallest household increase indicated on Table 7-11 would represent a 7.0 percent price hike and the largest would represent a 336 percent price hike. Correspondingly, a base price of $0.30 per 1,000 gallons would mean a rate increase of 14.1 percent at the low end of the scale and 672 percent at the high end. Due to the wide range of base rates across different systems, it is impossible to develop a realistic "average" rate. A range of rates, however, is included in Table 7-12.

Historically, industrial and commercial water usage has been inelastic to price increases.[1] For residential (household) customers, water appears price elastic with respect primarily to lawn sprinkling (see Section 6.2.3). Yet this does not necessarily mean that higher treatment costs can be passed to customers readily in the form of higher rates. If price elasticity is -0.65, as Gottlieb believes, and prices increase 100 percent, as they well may in small systems requiring expensive treatments, then total revenue to water suppliers will fall (see Table 6-9). Total revenues, rather than rates *per se*, are the critical figures for water suppliers. As demand falls in the first round of rate hikes, a second stage increase may be necessary to cover the largely fixed costs of water treatment.

Financial implications aside, the political repercussions of increasing water rates dramatically could be substantial. Unless local customers clearly understand the reasons behind the interim primary regulations and the related rate hikes, they may reject both. The mandatory notification criteria of the proposed regulations would serve to inform the local residents of contaminant problems associated with their water.

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[1] Patterson et al., "Water Use," *JAWWA*, 1973.

## TABLE 7-11

## PRICE IMPACTS OF REPRESENTATIVE TREATMENTS BASED ON PRESENT AVERAGE DISTRIBUTION OF TOTAL COSTS

| | | Systems Size Population Served | | |
|---|---|---|---|---|
| | **Chlorination Only** | **100[b]** | **5,000[c]** | **100,000[d]** |
| 1. | Increase in Unit Cost (cents/1,000 gal) | 15.48 | 3.48 | 3.06 |
| 2. | Total Annual Systems Increase (dollars)[a] | 616 | 9,780 | 194,300 |
| 3. | Increase in Household Unit Cost (cents/1,000 gal)[e] | 21.46 | 4.82 | 4.24 |
| 4. | Increase in Commercial Unit Cost (cents/1,000 gal)[f] | 10.89 | 2.45 | 2.15 |
| 5. | Increase in Industrial Unit Cost (cents/1,000 gal)[g] | 6.52 | 1.47 | 1.29 |
| 6. | Increase in Other Unit Cost (cents/1,000 gal)[h] | 17.03 | 3.83 | 3.37 |

| | | Systems Size Population Served | | |
|---|---|---|---|---|
| | Clarification Only | 100[b] | 5,000[c] | 100,000[d] |
| 1. | Increase in Unit Cost (cents/1,000 gal) | 142.04 | 30.33 | 20.04 |
| 2. | Total Annual Systems Increase (dollars)[a] | 5,651 | 85,238 | 1,272,510 |
| 3. | Increase in Household Unit Cost (cents/1,000 gal)[b] | 196.92 | 42.05 | 27.78 |
| 4. | Increase in Commercial Unit Cost (cents/1,000 gal)[c] | 99.95 | 21.34 | 14.10 |
| 5. | Increase in Industrial Unit Cost (cents/1,000 gal)[d] | 59.81 | 12.77 | 8.44 |
| 6. | Increase in Other Unit Cost (cents/1,000 gal)[e] | 156.24 | 33.36 | 22.04 |

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[a] Costs include annualized capital costs plus O&M plus monitoring.

[b] Based on 109 gallons (0.412 $m^3$) per capita day production.

[c] Based on 154 gallons (0.582 $m^3$) per capita day production.

[d] Based on 174 gallons (0.658 $m^3$) per capita day production.

[e] Assumes residential customers pay 61 percent of total costs and use 44 percent of output.

[f] Assumes commercial customers pay 19 percent of total costs and use 27 percent of output.

[g] Assumes industrial customers pay 8 percent of total costs and use 19 percent of output.

[h] Assumes other sales pay 11 percent of total costs and use 10 percent of output.

TABLE 7-12

## SAMPLE OF WATER RATES ACROSS THE COUNTRY

| CITY | POPULATION SERVED | RATE PER 1,000 GALLONS |
|---|---|---|
| Bradenton, Fla. | 70,000 | 80¢ for first 20,000<br>72¢ for next 80,000 |
| Wheeling, W. Va. | 50,000 | 120¢ for first 1,000<br>33¢ for next 99,000 |
| Elkhart, Ind. | 40,000 | 30¢ for first 3,300<br>18¢ for next 30,000 |
| Carlsbad, N. Mex. | 25,000 | 450¢ minimum for first 3,000<br>15¢ for all else |
| Borger, Tex. | 14,000 | 300¢ minimum for first 2,000<br>85¢ for next 8,000 |
| Honolulu, Hawaii | 545,000 | 37¢ for first 50,000<br>30¢ for next 350,000 |
| Tucson, Ariz. | 284,000 | 500¢ minimum for first 5,300<br>34¢ for next 23,000 |
| Kingsport, Tenn. | 43,000 | 80¢ for first 2,500<br>50¢ for next 22,500 |
| Arcadia, Fla. | 7,300 | 300¢ minimum for first 4,000<br>60¢ for next 11,000 |
| Lancaster, Pa. | 150,000 | 60¢ for first 75,000<br>43¢ for next 925,000 |
| Dayton, Ohio | 500,000 | 400¢ minimum for first 1,000<br>31¢ for next 9,000 |

Source: Elroy F. Spitzer, ed., Modern Water Rates (8th edition), American City Magazine, publisher (Pittsfield, Mass.: Buttenheim Publishing Co., 1972).

In 1974 the water industry spent about $1.5 billion on capital improvements.[1] Since the 5-year average total annual capital expenditures mandated by the proposed interim regulations are only 13 to 24 percent of this figure, it is anticipated that the industry as a whole would be able to raise the additional necessary capital. As Table 7-6 shows, however, the financial burden does not fall equally across the industry. Small firms may encounter difficulty in financing new treatment facilities, particularly when ion exchange, a relatively expensive process, is required (see Section 6.1).

## 7.3 Macroeconomic Effects

The macroeconomic effects of the Proposed Interim Primary Drinking Water Regulations are expected to be minimal. On the average, the regulations will cause an increase in water rates of 9.5 percent spread over several years. If this increase occurred in 1 year, the resulting increase in the Consumer Price Index (CPI) would be less than 0.001 percent. Since the costs of these regulations will be incurred over several years, the average annual increase in the CPI will be even less. The Chase Econometric Model predicts an estimated average annual increase in the CPI of less than 0.1 percent due to all pollution abatement programs.[2]

## 7.4 Energy Use

It is estimated that approximately 21,200 billion Btu's per year will be required to operate plants and produce chemicals for the various treatment systems necessary for the 40,000 community systems to meet the regulations. This is 0.028 percent of the 1973 national energy consumption, based on the 1974 Statistical Abstract. The increase in energy use will depend on a number of factors, including whether pollution in surface sources of waters is successfully controlled. There will be no direct energy savings from the recommended action.

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[1] U.S. Department of Commerce, U.S. Industrial 1970 Outlook (Washington, D.C.), p. 17.

[2] Chase Econometric Associates, Inc., "The Macroeconomic Impacts of Federal Pollution Control Programs," prepared for the Council of Environmental Quality and the Environmental Protection Agency, January 1975.

# CHAPTER EIGHT

## LIMITS OF THE ANALYSIS

### 8.0 Introduction

This chapter reviews the major assumptions of this report in order to bring the costs developed into proper perspective. Further, the limitations of each assumption are explored.

### 8.1 Assumptions in Developing Monitoring Costs

The dominant assumption used in developing monitoring costs is that the EPA Inventory of Community Water Systems provided an accurate description of the population of water supplies in the United States. This report further assumes that the EPA projection of 40,000 community water supplies is valid. There is some evidence from an ERCO survey of state agencies that this estimate is low by a factor of 20 percent, thereby causing the projected monitoring costs to be low by 20 percent as well.

The EPA estimate of 200,000 public non-community systems is also accepted as valid in this study. No conclusive evidence has been uncovered which either confirms or refutes this estimate.

The monitoring costs were developed from the following assumptions:

1. Only the minimal routine monitoring mandated by the Proposed Interim Primary Drinking Water Regulations would be performed;
2. A range of between 7 and 30 coliform measurements would be made for each coliform violation found;
3. A range of between 8 and 52 analyses will be performed for each organic and inorganic violation found.

It is quite possible that many systems, particularly those systems with chemical and biological laboratories, will choose to sample at a more frequent rate than that mandated by the regulations. Likewise, it is possible that many systems will analyze multiple samples to calculate one-month, three-month or yearly moving averages to determine if a system is in or out of compliance. Until a more complete data base is developed, it is impossible to predict the number of systems which will perform multiple sampling to assure compliance with the Interim Primary Drinking Water Regulations.

Special monitoring and treatment costs are all developed from the 1969 CWSS study of 969 water supply plants in nine regions of the country. These systems were not chosen randomly, but rather to represent specific water source characteristics (see Appendix K). The CWSS study therefore has several inherent biases which are magnified in projecting special national monitoring costs.

This report made no estimate on the costs of turbidity monitoring for the 40,000 community systems and the 2,000 to 5,000 public non-community systems which will need to make turbidity measurements to comply with the Interim Primary Drinking Water Regulations. It was assumed that turbidity sampling is presently being performed at each site. It is useful, however, to examine the costs of this monitoring activity. If one assumes that it takes 10 minutes to collect and analyze each turbidity sample, then 505 man-years of effort would be required nationally to satisfy the turbidity monitoring requirement. Assuming a salary of $4.00 per hour and an overhead rate of 100 percent, labor alone would cost $1.33 per turbidity analysis.

## 8.2 Assumptions in Developing Treatment Costs

The assumptions regarding the number of systems and the validity of the CWSS data base, as developed in the previous section, are equally important in this section.

In preparing estimates for total national treatment costs of implementation of the Proposed Interim Primary Drinking Water Regulations, a set of treatment assumptions was developed by EPA personnel. These assumptions can be summarized as follows:

1. Disinfection equipment will be installed in 27.5 percent of community surface and ground systems which do not presently disinfect. This percentage was arrived at by assuming 15 percent of the systems analyzed the first year would fail, and 15 percent of the remainder would fail during the second year;

2. All community surface systems which do not presently clarify will be forced to install clarification equipment;

3. All systems which violated one or more maximum contaminant levels (MCL) in the 1969 CWSS study will be forced to treat for the MCL; furthermore, the systems of the CWSS are considered representative of the nation's water systems as a whole.

Once the assumptions were developed to establish which systems would need treatment, a treatment technology was assigned to each MCL. The technology and MCL are listed in Table 8-1.

TABLE 8-1

TREATMENT TECHNOLOGY FOR MCL

| TREATMENT TECHNOLOGY | MCL |
|---|---|
| Clarification (direct filtration) | Turbidity |
| Ion Exchange | Ba, Cd, Cr, Hg, $NO_3$, Se, CN, Ag |
| Chlorination | Coliform |
| Activated Carbon | CCE |
| Activated Alumina | Fluoride, As |
| pH Control | Lead |

The EPA inventory of water supply systems was then utilized to determine the number of systems which presently do not treat for turbidity and coliform. It was decided that if a surface system has no coagulation unit, then it would need to install a direct filtration unit to meet the turbidity requirement of the proposed interim regulations.

It is believed that if the treatment technologies are uniformly applied to the existing 40,000 supply systems, the goal of safe drinking water will be met. The $1.1 to $1.8 billion capital requirement developed represents the cost of reaching this goal.

There are several reasons why the $1.1 to $1.8 billion capital requirement estimated to implement the Proposed Interim Primary Drinking Water Regulations may not be a maximum amount. In calculating the treatment costs for turbidity control, direct filtration was chosen as the most suitable technology. While it is true that direct filtration offers a reasonable treatment for those systems with turbidity under 100 JTU, it is not practical if the turbidity of the water is consistently above this level. Therefore, it is highly likely that many systems might desire to install the more expensive coagulation, sedimentation, and filtration technology to insure more uniform quality effluent during periods of high turbidity. The capital and annual O&M expenses calculated for turbidity control using direct filtration versus coagulation, sedimentation, and filtration are shown in Table 8-2.

In developing the national capital cost estimates, no attempt was made to assign turbidity control costs to the 1,366 mixed surface and ground systems. If a mixed source system obtains the majority of its water from a surface source, then it is probable that some form of clarification will be required.

In this study it was assumed that only 27.5 percent of the water systems not presently chlorinating would need to disinfect their water supplies; this includes both surface and ground sources of water. It is possible that more systems may need some form of disinfection to meet the coliform standards.

Likewise, there are several reasons why the projected capital requirement may be higher than actual requirements. One important assumption is that all plants which exceed a maximum contaminant level will use a treatment process to correct their problem, when in reality a great number of

## TABLE 8-2

## COMPARISON OF TURBIDITY CONTROL COSTS

| POPULATION SERVED | CLARIFICATION COSTS ASSUMING COAGULATION, SEDIMENTATION, FILTRATION ($) | CLARIFICATION COSTS ASSUMING DIRECT FILTRATION ($) |
|---|---|---|
| 25-99 | 220,000 | 21,000 |
| 100-499 | 300,000 | 30,000 |
| 500-999 | 370,000 | 41,000 |
| 1,000-2,499 | 430,000 | 52,000 |
| 2,500-4,999 | 480,000 | 150,000 |
| 5,000-9,999 | 530,000 | 270,000 |
| 10,000-99,999 | 1,400,000 | 640,000 |
| 100,000-999,999 | 7,200,000 | 3,400,000 |
| ≥ 1,000,000 | 41,000,000 | 22,000,000 |

plants will blend water which already meets the standards with water which exceeds the standards. Blending would reduce the costs of those systems which must treat for $NO_3$, Se, Cd, Cr, As, Hg, and Ba violations, but would not affect costs associated with chlorination and clarification. In the 1975 ERCO survey of 207 water supply systems which violated one or more maximum contaminant levels in the 1969 CWSS study, ERCO found five systems which treated for $NO_3$ and Se problems subsequent to the 1969 CWSS study (Appendix D, Table D-2). All five of these systems employed blending rather than the more expensive ion exchange treatment. Since ion exchange processes account for almost 35 percent of the total treatment costs this could be an important consideration.

The treatment costs developed do not consider any possible benefits to be derived from the cascading of treatment processes. In many cases it is possible to treat several contaminants simultaneously, thereby reducing costs. In particular, coagulation and direct filtration may remove many contaminants which are associated with turbidity in the water. Engineering tests are necessary to establish the feasibility of this approach. However, with the limited data available it is impossible to quantify the benefits to be derived from cascading. Likewise, it is impossible to quantify any beneficial effects attributable to the retrofitting of treatment processes. There are 2,126 water systems which would install clarification equipment. These systems could have large retrofit interactions which could have a large effect on costs (Appendix I).

In developing the treatment costs, it became apparent that considerable attention should be given to the costs which would be borne by small (under 1,000 population served) water systems. Table 8-3 lists the capital costs associated with each treatment technology for the systems serving 1,000 or fewer people. When one looks at the capital costs for clarification and ion exchange for these small systems, it is apparent that the per capita burden of treatment is too great for any small community to bear. It is equally true, however, that these small systems will need to comply with the Interim Primary Drinking Water Regulations in the same manner as will larger systems if these regulations are accepted in the proposed form.

The small systems (as well as larger systems) would probably consider the following options rather than install expensive treatment processes:

TABLE 8-3

## CAPITAL TREATMENT COSTS FOR SMALL WATER SYSTEMS[a] USING CURRENT PRODUCTION RATES

| POPULATION SERVED GROUP | DISINFECTION | CLARIFICATION | ION EXCHANGE | pH CONTROL | ACTIVATED ALUMINA | ACTIVATED CARBON |
|---|---|---|---|---|---|---|
| 25-99 | 690 | 21,000 | 41,000 | 400 | 2,600 | 1,500 |
| 100-499 | 1,200 | 30,000 | 68,000 | 800 | 6,100 | 4,300 |
| 500-999 | 1,800 | 41,000 | 100,000 | 1,200 | 12,000 | 10,000 |

[a] Based on average sized systems in the EPA Inventory of Community Water Supply Systems.

1. Shift source of water from surface to ground;
2. Change groundwater sources;
3. Consolidate (merge systems);
4. Purchase finished water;
5. Disband the community system and go to individual well sources.

It is possible to develop cost data for options 1 and 2. In both of these options it is necessary to develop well costs, which are dependent on the initial cost of structures and equipment, the useful life of structures and equipment, and the cost of operation and maintenance. As in any engineering project, it is possible to vary the costs of all three cost factors. A complete description of well costs can be found in Rural Water Systems Planning and Engineering Guide by Campbell and Lehr.[1] For purposes of illustration, the cost will be developed for a 6-inch diameter 80-foot deep medium high capacity sand well using a 40-gallon per minute submersible turbine pump with 400 feet total lead. The well cost of $6,177 includes setting up and removing the drilling equipment, drilling the well (test drilling not included), all casings and liners including construction casings, grouting and sealing the annular spaces between casings and between casings and the boreholes, well screens and fittings, gravel pack materials, and placing and conducting one 8-hour pumping test. Not included in this estimate are preliminary hydraulic tests and site exploration. The submersible pump would cost $3,921. It is anticipated that the pump will remain maintenance-free for a period of 5 years before major repairs would be instituted. A third cost associated with the construction of a new water system is the water transmission cost. For example, it would cost $35,000 per mile to lay a 6-inch diameter pipe. Finally, any treatment costs associated with the new water source must be considered. Briefly summarizing the results of this example, it would cost $10,098 to construct the well and install a pump, with a cost of $35,000 per mile for transmission lines.

If systems choose options 3 or 4 above, then the primary cost to consider is the cost of the transmission lines to furnish water to all parts of the system from the new source.

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[1] Michael D. Campbell and Jay H. Lehr, Rural Water Systems Planning and Engineering Guide, Commission on Rural Water (Washington, D.C., 1973).

Figure 8-1 shows the equivalent monthly cost of operating a single domestic well. A typical well would cost $1,200 to drill and the average low capacity pumping system would cost $980.[1] It would cost about $22 per month to run a single-family well. Presumably, if municipal water costs exceeded this cost and groundwater sources were available, people would choose to develop their own water source rather than purchase water from a community system.

Table 8-4 shows the total national costs of applying the recommended treatment technologies to comply with the Interim Primary Drinking Water Regulations. It is apparent that many of these costs will not be spent on treating these small systems. What is not known, however, is the number of systems which will purchase water from existing systems, thereby increasing treatment costs for those systems. Until these two factors can be determined, it appears reasonable to assign the costs to small systems even though they may not ultimately treat their present source of water.

## 8.3 Assumptions Inherent in the Constraint Analysis

It is assumed that in the coming decade polyelectrolytes will largely replace inorganic salts as the predominant coagulants, thereby increasing the demand for the former material.

It is anticipated that manpower needs will follow the historical patterns, although an increase in monitoring and reporting functions could cause an increase in the personnel required to fulfill these functions.

## 8.4 Other Assumptions

A 7 percent interest rate is assumed on all capital financing. This is somewhat more than a municipality might have to pay, but less than might be paid by an investor-owned utility. A 15-year pay back period was assumed. In general, systems may choose larger pay back periods, but the overall effect of changing pay back periods and interest

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[1] Campbell and Lehr, Rural Water Systems Planning and Engineering Guide, 1973.

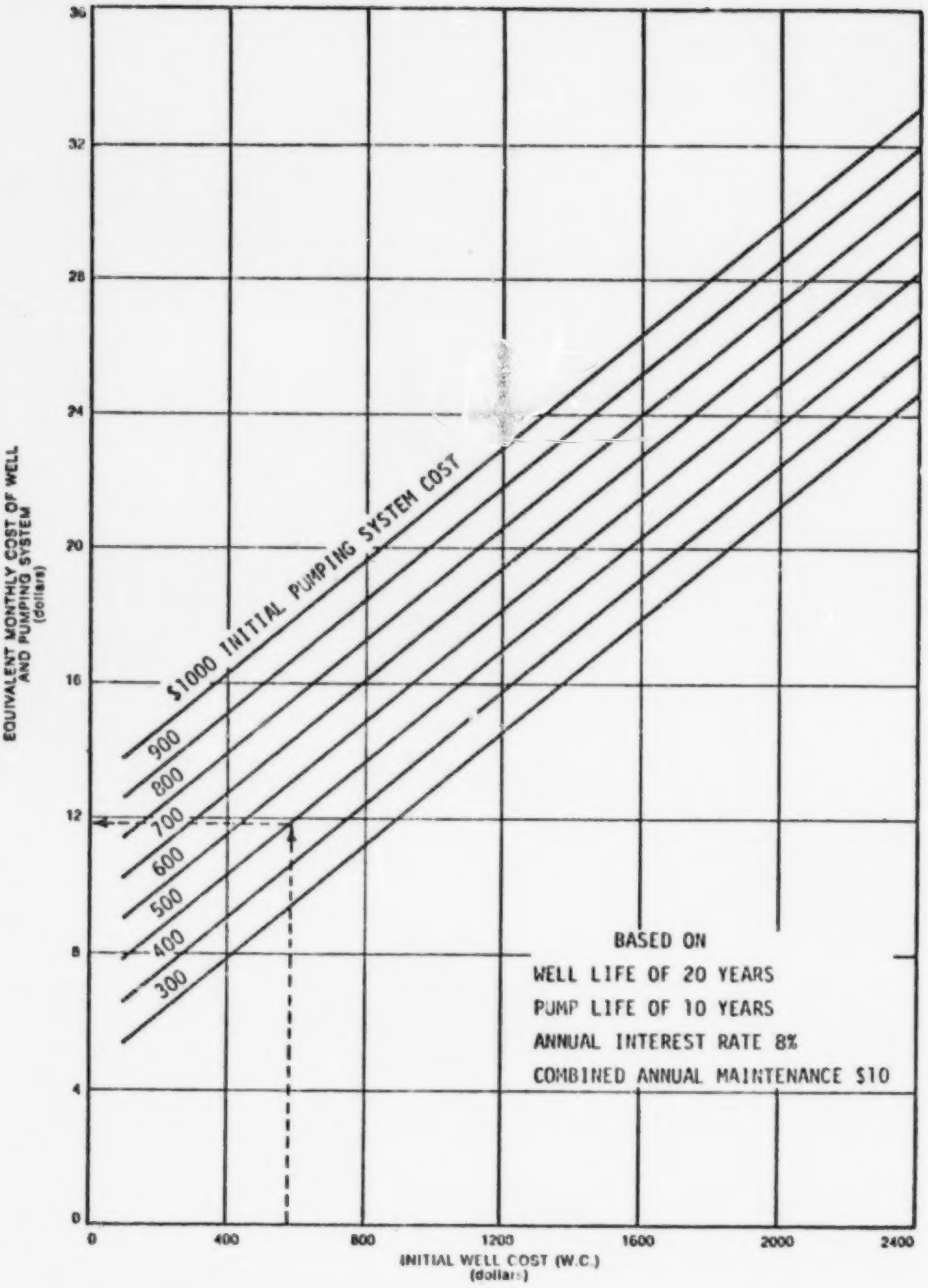

Figure 8-1. This figure displays the monthly cost of wells and pumping systems. (Michael D. Campbell and Jay H. Lehr, Rural Water Systems Planning and Engineering Guide, p. 119.)

## TABLE 8-4

## ION EXCHANGE AND CLARIFICATION COSTS ASSIGNED TO SMALL COMMUNITY SYSTEMS

| POPULATION SERVED GROUP | CLARIFICATION COSTS ($ 1,000) | ION EXCHANGE COSTS ($ 1,000) | SUM OF CLARIFICATION AND ION EXCHANGE TOTAL COSTS ($ 1,000) |
|---|---|---|---|
| 25-99 | 5,292 | 22,878 | 28,170 |
| 100-499 | 19,590 | 69,728 | 89,318 |
| 500-999 | 12,013 | 33,700 | 45,713 |
| TOTAL SMALL SYSTEM COST | 36,895 | 126,306 | 163,201 |
| TOTAL NATIONAL COST TREATMENT | 378,338 | 619,204 | 997,542 |
| PERCENT OF TOTAL NATIONAL TREATMENT COSTS | 9.7 | 20.1 | 16.4 |

rates is not great since the majority of annual expenditures go into O&M costs rather than financing charges. No assumption is made on the rate of inflation which will occur in the coming decade. All costs are based on 1975 dollars with no factor for inflation.

CHAPTER NINE

# EXAMINATION OF ALTERNATIVES TO THE INTERIM PRIMARY DRINKING WATER REGULATIONS

## 9.0 Introduction

The first eight chapters of this report developed the costs of implementing the Proposed Interim Primary Drinking Water Regulations, while this chapter determines the effect on costs and manpower which would be caused by altering the Interim Primary Drinking Water Regulations as published in the *Federal Register* on March 14, 1975 (see Appendix J).

In this chapter three sets of alternatives are examined. The major alternatives are summarized in Table 9-1. These alternatives are illustrative of possible changes in the interim regulations which could reduce the impact of the regulations. Table 9-2 illustrates the changes which would occur upon implementation of the alternative sets of regulations.

## 9.1 Effect of Changing the Definition of "Community" Water System

The factors which determine the overall monitoring costs caused by implementation of any regulations are the laboratory costs, the source of water, and the number of community and non-community systems. The first two factors, laboratory costs and source of water, were discussed in Chapter Four. This section will explore the impact of changing definitions on the number of community and non-community systems, while the following sections will delineate the effects on overall monitoring costs caused by superimposing the definition changes on the other alternative changes.

The regulations published in the *Federal Register* define a "community water system" as a public water system which serves a population of which 70 percent or greater of the total are residents. Using this definition it has been estimated that there are 40,000 public water systems which meet this definition, with 200,000 public water systems which would be classified as non-community systems.

## TABLE 9-1

## ALTERNATIVE MONITORING OPTIONS

| ALTERNATIVE | | REGULATIONS | SET 1 | SET 2 | SET 3 |
|---|---|---|---|---|---|
| I | DEFINITION OF COMMUNITY SYSTEM | | | | |
| | A) 15 service connections or 25 residents | X | | | X |
| | B) 15 service connections or serves non-transient populations | | X | | |
| | C) 70 percent residents with 15 connections and 25 people served | | | X | |
| II | PLATE COUNT | | | | |
| | A) 10 percent of coliform, 1 per month | X | | | |
| | B) Deleted | | X | X | X |
| III | COLIFORM | | | | |
| | A) 2 per month for systems serving under 1,000 people | X | | | |
| | B) 1 per month for systems serving under 1,000 people | | X | X | X |
| IV | TURBIDITY | | | | |
| | A) Daily sampling for all systems | X | | | |
| | B) Sampling not required for groundwater sources | | X | X | X |
| V | PESTICIDE SAMPLING | | | | |
| | A) Monitor surface sources yearly and groundwater sources at 3-year intervals | X | X | | |
| | B) Monitor surface sources yearly and groundwater at State discretion | | | X | |
| | C) Monitor surface sources within 3-year intervals and groundwater sources at State discretion | | | | X |
| VI | ORGANIC (CCE) SAMPLING | | | | |
| | A) Monitor surface sources yearly and groundwater sources every 3 years | X | X | | |
| | B) Monitor surface sources yearly and groundwater sources at State discretion | | | X | |
| | C) Deleted | | | | X |
| VII | SPECIAL MONITORING | | | | |
| | A) Monthly monitoring for systems between 75 and 100 percent of MCL | X | | | |
| | B) No special monitoring between 75 and 100 percent of MCL | | X | X | X |
| | C) Weekly sampling for exceeding MCL | X | X | X | |
| | D) Three check analyses within 1 month | | | | X |
| | E) Daily sampling for coliform violations | X | X | X | |
| | F) Minimum of 2 samples done at State discretion | | | | X |
| VIII | NON-COMMUNITY SYSTEMS | | | | |
| | A) Monthly coliform sampling required | X | | | |
| | B) Semi-annual coliform monitoring required | | X | | |
| | C) State discretion for coliform monitoring | | | X | |
| | D) Quarterly coliform monitoring | | | | X |
| | E) Total organic and inorganic analyses | X | | | |
| | F) State discretion for complete organic and inorganic analyses | | X | X | |
| | G) $NO_3$ analysis only at State discretion | | | | X |

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## TABLE 9-2

## COSTS OF ALTERNATIVE MONITORING OPTIONS

| ALTERNATIVE | | REGULATIONS | SET 1 | SET 2 | SET 3 |
|---|---|---|---|---|---|
| I | DEFINITION OF COMMUNITY SYSTEM (# of systems) | | | | |
| | A) 15 service connections or 25 residents | 40,000 | | | 40,000 |
| | B) 15 service connections or serves non-transient populations | | 80,000 | | |
| | C) 70 percent residents with 15 connections and 25 people served | | | 36,248 | |
| II | PLATE COUNT (cost, $ million) | | | | |
| | A) 10 percent of coliform, 1 per month | 3.0-5.9 | | | |
| | B) Deleted | | 0 | 0 | 0 |
| III | COLIFORM (cost, $ million) | | | | |
| | A) 2 per month for systems serving under 1,000 people | 3.3-6.6 | | | |
| | B) 1 per month for systems serving under 1,000 people | | 3.3-6.6 | 0.5-0.9 | 0.7-1.3 |
| IV | TURBIDITY | | | | |
| | A) Daily sampling for all systems | - | | | |
| | B) Sampling not required for groundwater sources | | - | - | - |
| V | PESTICIDE SAMPLING (cost, $ million) | | | | |
| | A) Monitor surface sources yearly and groundwater sources at 3-year intervals | 2.4-4.1 | 4.4-7.4 | | |
| | B) Monitor surface sources yearly and groundwater sources at discretion | | | 0.9-1.5 | |
| | C) Monitor surface sources within 3-year intervals and groundwater sources at State discretion | | | | 0.3-0.5 |
| VI | ORGANIC (CCE) SAMPLING (cost, $ million) | | | | |
| | A) Monitor surface sources yearly and groundwater sources every 3 years | 0.8-1.2 | 1.5-2.1 | | |
| | B) Monitor surface sources yearly and groundwater sources at State discretion | | | 0.3-0.4 | |
| | C) Deleted | | | | 0 |
| VII | SPECIAL MONITORING (cost, $ million) | | | | |
| | A) Monthly monitoring for systems between 75 and 100 percent of MCL | 1.1-2.7 | | | |
| | B) No special monitoring between 75 and 100 percent of MCL | | 0 | 0 | 0 |
| | C) Weekly sampling for exceeding MCL | 0.3-3.0 | 0.3-3.0 | 0.3-3.0 | |
| | D) Three check analyses within 1 month | | | | .01-0.3 |
| | E) Daily sampling for coliform violations | 0.1-0.5 | 0.1-0.5 | 0.1-0.5 | |
| | F) Minimum of 2 samples done at state discretion | | | | .05-0.2 |
| VIII | NON-COMMUNITY SYSTEMS (# of systems) | 200,000 | 160,000 | 203,752 | 200,000 |
| | A) 2/month coliform monitoring required (cost, $ million) | 24-48 | | | |
| | B) Semi-annual coliform monitoring required | | 1.6-3.2 | | |
| | C) State discretion for coliform monitoring | | | 0 | |
| | D) Quarterly coliform monitoring | | | | 4.0-8.0 |
| | E) Total organic and inorganic analyses | 9.3-16.7 | | | |
| | F) State discretion for complete organic and inorganic analyses | | 0 | 0 | |
| | G) $NO_3$ analysis only at State discretion | | | | 1.1-2.7 |
| | I) 2/month plate count | 12-24 | | | |

The Set 1 alternative definition would define a "community water system" as a public water system which has at least 15 service connections or which serves a non-transient population. The term includes public water systems providing water to residential communities, schools, factories, office buildings and other facilities in which the same 25 or more people regularly consume the drinking water. The term does not include public water systems which provide water only to gas stations, restaurants, or campgrounds, or those which are carriers which convey passengers in interstate commerce. The net effect of changing the definition of a community system would be to increase the number of systems in that category from 40,000 to about 80,000 with a concomitant decrease in non-community systems from 200,000 to 160,000. This estimate is based on the distribution of non-community systems in New York State (Appendix C).

In the Set 2 alternatives the definition of a "community system" was changed to mean a public water system that serves 15 service connections and 25 residents regularly throughout the year. Implementation of this new definition would serve to eliminate those systems which do not meet both the population served and service connection criteria. A breakdown of the present EPA inventory of water systems showed 113 surface, 626 ground, and 117 other water systems out of 31,000 which served 24 or fewer residents. This means that, projected nationally, 1,104 systems would not meet the population served criterion. A random sample of 136 plants from the EPA data base was used to determine the number of plants which serve 25 or more residents but have fewer than 15 service connections. Using this random sample, it was determined that 2,648 systems nationally would not meet this criterion. The costs developed in the remainder of this section were derived for those 36,248 systems which would be considered as "community systems" under the new definition. This would increase the number of non-community systems to 203,752.

The Set 3 definition of community systems was similar to the published version and would mean that the number of community systems would remain at 40,000.

## 9.2 Monitoring

The national costs of implementation of the different monitoring options for all three sets are shown in Table 9-2, while the national cost summaries are shown in Table 9-3.

TABLE 9-3

## TOTAL MONITORING COSTS FOR THREE SETS OF MONITORING ALTERNATIVES

| | COMMUNITY SYSTEMS | REGULATIONS ($ million) | SET 1 ($ million) | SET 2 ($ million) | SET 3 ($ million) |
|---|---|---|---|---|---|
| A. | Costs of Routine Monitoring | 22.2-42.8 | 24.9-48.0 | 16.7-32.1 | 13.3-27.3 |
| B. | Monitoring Costs for Chemical Violations | 0 | 0.1-0.4 | 0.0-0.3 | 0.0-0.2 |
| C. | Monitoring Costs Due to Coliform Violations | 0.2-1.5 | 0.7-5.3 | 0.2-1.5 | 0.0-0.3 |
| D. | Monitoring Costs Between 75 to 100 Percent of MCL | 0.6-1.4 | 0 | 0 | 0 |
| | NON-COMMUNITY SYSTEMS | REGULATIONS | SET 1 | SET 2 | SET 3 |
| A. | Costs of Routine Monitoring | 47.1-92.0 | 1.8-3.4 | 2.1-4.2 | 4.5-9.4 |
| B. | Monitoring Costs for Chemical Violations | 0.3-2.1 | 0 | 0.3-2.1 | 0.3-0.8 |
| C. | Monitoring Costs Due to Coliform Violations | 0.5-6.8 | 0 | 0 | 0 |
| D. | Monitoring Costs Between 75 to 100 Percent of MCL | 0.8-1.9 | 0 | 0 | 0 |
| | SUBTOTAL COMMUNITY | 23.0-46.0 | 25.7-53.7 | 16.9-33.9 | 13.3-27.8 |
| | SUBTOTAL NON-COMMUNITY | 48.7-102.8 | 1.8-3.4 | 2.4-6.3 | 4.8-10.2 |
| | TOTAL | 71.7-148.4 | 27.5-57.1 | 19.3-40.2 | 18.1-38.0 |

While all monitoring options considered show substantially less monitoring costs than do the proposed regulations, the third set of alternatives results in the lowest overall costs.

Table 9-4 shows the per capita effects of the three sets of alternatives and the proposed regulations. The costs are based on the monitoring schedule for the third year in all cases. For the surface-water systems, full inorganic surveys are costed at $78 to $188 for the proposed regulations and Alternative Sets 1 and 2, and costed at $70 to $170 for Alternative Set 3. Organic surveys are costed at $200 to $312 for the proposed regulations and Alternative Sets 1 and 2, and at $150 to $250 for Alternative Set 3.

For groundwater systems the cost of an inorganic survey is the same as for surface-water systems while the cost of organic surveys varies from $66.67 to $104 for the proposed regulations and Alternative Set 1, to 0 for Sets 2 and 3. In the case where systems purchase finished water, it is assumed that no chemical monitoring would be needed since the parent system would satisfy the monitoring requirements. For each type of system, the required number of coliform and plate count tests are assumed and each test is costed at $5 to $10.

## 9.3 Effect of Alternative Monitoring Options on Treatment Requirements

The only effect on treatment requirements which would be caused by the alternative sets of monitoring options would occur in Set 3, when the CCE monitoring requirement is dropped. Since no system would be required to monitor for this MCL, the costs for treating organic matter in water would no longer be incurred. This would lessen the total capital treatment costs by $22.5 million and the annual O&M costs by $4.5 million.

## 9.4 Manpower Requirements

Table 9-5 delineates the manpower requirements which would be expected upon implementation of any of the three sets of options. It is estimated that personnel requirement would total 26,600 to implement the proposed regulations, with 45,600 for Set 2 and 22,700 for Set 3. The main

## TABLE 9-4

## ANNUAL MONITORING COSTS PER PERSON FOR THREE SETS OF MONITORING ALTERNATIVES

| SYSTEM SIZE | REGULATIONS |  | ALTERNATIVE 1 |  | ALTERNATIVE 2 |  | ALTERNATIVE 3 |  |
|---|---|---|---|---|---|---|---|---|
|  | SURFACE ($ million) | GROUND | SURFACE ($ million) | GROUND | SURFACE ($ million) | GROUND | SURFACE ($ million) | GROUND |
| 25 | 18.32-34.40 | 11.57-21.07 | 15.92-29.60 | 8.51-16.27 | 15.92-29.60 | 5.84-12.11 | 7.20-15.05 | 3.35-7.05 |
| 100 | 4.58-8.60 | 2.73-5.27 | 3.98-7.40 | 2.13-4.07 | 3.98-7.40 | 1.46-3.02 | 2.40-3.75 | 0.85-1.75 |
| 250 | 1.83-3.44 | 1.16-2.11 | 1.59-2.96 | 0.85-1.63 | 1.59-2.96 | 0.58-1.21 | 0.72-1.51 | 0.33-0.70 |
| 1,000 | 0.46-0.86 | 0.27-0.53 | 0.40-0.74 | 0.21-0.41 | 0.40-0.74 | 0.15 0.30 | 0.24-0.38 | 0.09-0.17 |
| 2,500 | 0.21-0.39 | 0.13-0.23 | 0.18-0.34 | 0.11-0.21 | 0.18-0.34 | 0.08-0.17 | 0.15-0.32 | 0.08-0.16 |

## TABLE 9-5

## SUMMARY OF MANPOWER REQUIREMENTS TO IMPLEMENT THREE SETS OF ALTERNATIVE MONITORING OPTIONS

| | TOTAL PERSONNEL REQUIRED | | | |
|---|---|---|---|---|
| FUNCTION | PROPOSED REGULATIONS | ALT. SET 1 | ALT. SET 2 | ALT. SET 3 |
| MONITORING | | | | |
| microbiological | 2,800 | 1,100 | 500 | 700 |
| chemical | 785 | 400 | 100 | 100 |
| turbidity | 500 | 355 | 175 | 175 |
| PROCESS OPERATION | 19,400 | 38,800 | 19,400 | 19,200 |
| PROGRAM ASSISTANCE | 375 | 550 | 375 | 375 |
| CLERICAL | 340 | 325 | 150 | 175 |
| PROGRAM ADMINISTRATION | 2,400 | 4,100 | 2,000 | 2,050 |
| TOTAL | 26,600 | 45,630 | 22,700 | 22,550 |

difference in personnel requirements between these two sets is the change in definition of "community systems," if the two definitions were the same as in the proposed regulations, about 23,500 personnel would be required. The difference in personnel requirements between Set 2 and Set 3 is due to dropping both the CCE monitoring and the process operations for activated carbon treatment.

## 9.5 Potential Manpower Saving for Water Quality Monitoring From Alterations to Prescribed Methods

All of the three sets of monitoring alternatives allow for monitoring procedures. This section will explore some of the available monitoring procedures which could be implemented to reduce monitoring manpower requirements.

Manpower data supplied by Earl McFarren of EPA, Cincinnati,[1] show that the most efficient chemical analyses can be performed at a rate of about 600 per man-month (30 per man-day, 7,200 per man-year). This estimate includes allowances for instrument adjustments, preparation of standards and calibrations curves, dishwashing, and (presumably) paperwork. Chemical constituents that can be analyzed at this frequency are those for which the water sample can be assayed directly without extensive pretreatment. Barium, chromium, and silver (for which direct aspiration into the flame of an atomic absorption (AA) spectrophotometer is suitable), as well as fluoride and nitrate (for which simple colorimetric methods are prescribed), all fall into this category.

Arsenic, selenium and mercury are analyzed at a slower rate of 400 samples per month. Sample preparation consists of chemical reduction to the gaseous species $AsH_3$, $SeH_2$, and mercury vapor. The $AsH_3$ and $SeH_2$ are vented to a conventional AA flame; mercury vapor is analyzed by flameless AA. Direct aspiration procedures exist for these metals, but they lack the necessary sensitivity for drinking water quality analyses. There seems to be little potential for making more efficient analyses for these elements.

Cyanide can be analyzed according to the prescribed method at the rate of 200 samples per month. Sample preparation (distillation) is the time-consuming step, but it is necessary for separating the cyanide ions from complex-forming metals. Again, there seems to be no way to expedite the analyses.

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[1] Personal communication - Earl McFarren, EPA, Cincinatti, Ohio, June 1975.

The most time-consuming analyses are for chlorinated hydrocarbons and herbicides. Here it is necessary to do a solvent extraction, followed by evaporation (and for the herbicides, esterification) before the gas chromatographic analysis can be performed. Again, there seem to be no time-saving alternatives.

Some time savings can be achieved in the analyses of lead and cadmium without a loss of accuracy. The standard method is preconcentration by chelation and extraction, followed by aspiration of the extract into a flame AA system. The need for preconcentration slows the rate of analysis by a factor of three. However, if the regulations were to permit the use of a graphite furnace for atomization, direct injection of samples would be possible, and the analysis rate would be 600 samples per man-month rather than 200.

There is potential for substantial savings in monitoring for overall organics. This would, however, require a change in the basis of the standard, presently set at 0.7 mg/l of carbon chloroform extractibles. CCE is taken as an index of overall organic contamination. The CCE process is tedious and the rate of analysis is about 60 samples per man-month.

If the organic standard were instead based on "total organic carbon," the analysis rate would increase to an estimated 600 samples per man-month, or a tenfold increase in efficiency. The potential manpower savings are shown in Table 9-6.

## 9.6 Summary of Alternative Monitoring Options

The first set of alternatives would generally cause reductions in the number of personnel, chemicals, and other key items. However, the change in the definition of community systems would temper these potential savings since it would increase the number of community systems from 40,000 to 80,000. If the definition of community systems was not changed, then the required manpower would be cut to approximately one-fourth the laboratory personnel necessary to implement the proposed interim regulations. In this short

## TABLE 9-6

## POTENTIAL MANPOWER SAVING BY SUBSTITUTION OF MORE EFFICIENT ANALYTICAL TECHNIQUES

| CONTAMINANT | MAN-YEAR EFFORT FOR NATIONWIDE MONITORING | | |
|---|---|---|---|
| | First Year | Second Year | Third Year |
| Lead-standard | 23.7 | 32.7 | 8.4 |
| Lead-graphite furnace | 10.9 | 10.9 | 2.8 |
| Manpower saved | 21.8 | 21.8 | 5.6 |
| Cadmium-standard | 19.3 | 19.3 | 8.4 |
| Cadmium-graphite furnace | 6.4 | 6.4 | 2.8 |
| Manpower saved | 12.9 | 12.9 | 5.6 |
| Organics-CCE | 70.5 | 70.5 | 28.0 |
| Organics-TOC | 7.1 | 7.1 | 2.8 |
| Manpower saved | 63.4 | 63.4 | 25.2 |
| TOTAL MANPOWER SAVED | 98.1 | 98.1 | 36.4 |

analysis it is assumed that the monitoring of public non-community systems will continue at the present rate, meaning that no additional costs would be incurred to monitor these systems.

Implementation of Alternative Set 2 or 3 would generally cause a substantial (75 percent) reduction in monitoring personnel with smaller reductions in auxiliary services. These sets of alternatives would reduce the per capita monitoring burden on smaller community and non-community systems.

## 9.7 Effects of Changing the CCE Level

This section examines the effect of changing the maximum contaminant level of CCE organics from the published value of 0.7 mg/l to either 0.5 or 0.15 mg/l. Table 9-7 shows that over 30 times as many plants would have to remove CCE organics if the maximum level were reduced from 0.7 to 0.15 mg/l.

If the 0.15 mg/l alternative CCE level were adopted, then an additional 12 percent of the current production of activated carbon would be required to remove this contaminant from the 40,000 drinking water systems (Table 9-8).

Despite the fact that reserves are extremely abundant (recoverable coal reserves are estimated at 1,500 billion tons), it would still take several years to build enough plants to produce the capacity estimated as necessary for meeting the 0.15 mg/l standard.

It would require a capital investment of $509.2 million to treat for CCE at the 0.15 mg/l level, while it would cost $22.5 million at the 0.7 mg/l level (Table 9-9).

## TABLE 9-7

## EFFECT OF CHANGING MAXIMUM LEVEL OF CCE

| FOR COMMUNITY SYSTEMS (mg/l) | CCE MAXIMUM LEVEL IMPACTS |
|---|---|
| 0.15 level impacts | 3,666 plants (77.4%) |
| 0.50 level impacts | 471 plants (9.95%) |
| 0.70 level impacts | 162 plant (3.42%) |

## TABLE 9-8

## ADDITIONAL PRODUCTION OF CARBON PER ANNUM TO REMOVE CCE ORGANICS FROM WATER

| MAXIMUM LEVEL CCE (mg/l) | TOTAL COMMUNITY PLANTS IMPACTED | PERCENT OF 40,000 PLANTS | INITIAL TONS CARBON REQUIRED | PERCENT CURRENT PROD.[a] | ADDED COST/YR ($ mil.) |
|---|---|---|---|---|---|
| 0.15 | 3,666 | 9.2 | 46,259 | 54.3 | 36.2 |
| 0.50 | 471 | 1.2 | 5,946 | 7.0 | 4.8 |
| 0.70 | 162 | 0.4 | 2,044 | 2.4 | 1.6 |

[a] Current Production = 85,000 tons/year (1974).

## TABLE 9-9

## TREATMENT COSTS FOR CCE ($ million)

| MAXIMUM LEVEL (mg/l) | IMPACTED PLANTS | CAPITAL INVESTMENT | O&M |
|---|---|---|---|
| 0.70 | 162 | 22.5 | 4.6 |
| 0.50 | 471 | 65.5 | 13.4 |
| 0.15 | 3,666 | 509.2 | 104.1 |

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# PROPOSED

# INTERIM PRIMARY DRINKING WATER STANDARDS

WATER SUPPLY DIVISION
OFFICE OF WATER AND HAZARDOUS MATERIALS
ENVIRONMENTAL PROTECTION AGENCY

# ENVIRONMENTAL PROTECTION AGENCY

## Subchapter D - Water Programs

## Part 141, Subpart A

## Interim Primary Drinking Water Standards

(Authority: Sections 1412, 1414, 1415 and 1450 of the Safe Drinking Water Act, P.L. 93-523)

### Section 141.1. Applicability.

This sub-part sets forth the interim primary drinking water standards required by Section 1412 of the Safe Drinking Water Act (P. L. 93-523).

### Section 141.2. Definitions.

As used in this sub-part:

(a) "The term 'Act' means the Safe Drinking Water Act, Public Law 93-523.

(b) "The term 'maximum contaminant level' means the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system.

(c) "The term 'public water system' means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least three months out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

(d) "The term 'supplier of water' means any person who owns or operates a public water system.

(e) "The term 'contaminant' means any physical, chemical, biological, or radiological substance or matter in water.

(f) "The term 'person' means an individual, corporation, company, association, partnership, State, municipality, or Federal agency.

(g) "The term 'State' means the agency of the State government which has jurisdiction over public water systems. During any period when a State does not have primary enforcement responsibility, the term 'State' means the Regional Administrator, Environmental Protection Agency.

(h) "the term 'community water system' means a public water system which serves a population of which 70% or greater are residents.

## Section 141.3 Coverage

The interim primary drinking water standards under this sub-part shall apply to each public water system in a state; except that such standards shall not apply to a public water system -

(a) which consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(b) which obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(c) which does not sell water to any person; and

(d) which is not a carrier which conveys passengers in interstate commerce.

### Sec. 141.11 Maximum Contaminant Levels for Inorganic Chemicals.

(a) The following are the maximum contaminant levels for inorganic chemicals:

| Contaminant | Level (mg/l) |
|---|---|
| Arsenic | 0.05 |
| Barium | 1. |
| Cadmium | 0.010 |
| Chromium | 0.05 |
| Cyanide | 0.2 |
| Lead | 0.05 |
| Mercury | 0.002 |
| Nitrate (as N) | 10. |
| Selenium | 0.01 |
| Silver | 0.05 |

(b) When the annual average of the maximum daily air temperatures for the location in which the public water system is situated is the following, the corresponding concentration of fluoride shall not be exceeded:

| Temperature (in degrees F) | (degrees C) | Level (mg/l) |
|---|---|---|
| 50.0 - 53.7 | 10.0-12.0 | 2.4 |
| 53.8 - 58.3 | 12.1-14.6 | 2.2 |
| 58.4 - 63.8 | 14.7-17.6 | 2.0 |
| 63.9 - 70.6 | 17.7-21.4 | 1.8 |
| 70.7 - 79.2 | 21.5-26.2 | 1.6 |
| 79.3 - 90.5 | 26.3-32.5 | 1.4 |

The requirements of this paragraph (b) do not apply to public water supplies serving only educational institutions.

Sec. 141.12 Maximum Contaminant Levels for Organic Chemicals.

The maximum contaminant level for the total concentration of organic chemicals, as determined by the carbon chloroform extract method set forth in sec. 141.24(b), is 0.7 mg/l.

## Sec. 141.13 Maximum Contaminant Levels for Pesticides

The following are the maximum contaminant levels for pesticides:

| (a) Chlorinated Hydrocarbons | Level mg/l |
|---|---|
| Chlordane (cis and trans)<br>(1, 2, 4, 5, 6, 7, 8, 8-Octachloro-3a, 4, 5, 7a-tetrahydro-4, 7-methanoindan) | 0.003 |
| Endrin<br>(1, 2, 3, 4, 10, 10-Hexachloro-6, 7-epoxy-1, 4, 4a, 5, 6, 7, 8, 8a-octahydro-1, 4-endo, endo-5, 8-dimethano naphthalene) | 0.0002 |
| Heptachlor<br>(1, 4, 5, 6, 7, 8, 8-Heptachloro-3a, 4, 7, 7a-tetrahydro 4, 7-methanoindene) | 0.0001 |
| Heptachlor Epoxide<br>(1, 4, 5, 6, 7, 8, 8, -Heptachloro-2, 3-epoxy-3a, 4, 7, 7a-tetrahydro-4, 7-methanoindan) | 0.0001 |
| Lindane<br>(1, 2, 3, 4, 5, 6-Hexachloro-cyclohexane, gamma isomer) | 0.004 |
| Methoxychlor<br>(1, 1, 1-Trichloro-2, 2-bis [p-methoxyphenyl] ethane) | 0.1 |
| Toxaphene<br>($C_{10}H_{10}Cl_8$ - Technical chlorinated camphene, 67-69% chlorine) | 0.005 |

### (b) Chlorophenoxys

| | |
|---|---|
| 2, 4-D<br>(2, 4-Dichlorophenoxyacetic acid) | 0.1 |
| 2, 4, 5-TP Silvex<br>(2, 4, 5-Trichlorophenoxypropionic acid) | 0.01 |

Sec. 141.14 Maximum Contaminant Level of Turbidity.

The maximum contaminant level of turbidity in the drinking water at a representative entry point(s) to the distribution system is one turbidity unit (TU), as determined pursuant to sec. 141.22 of this subpart, except that no greater than five turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not:

(a) interfere with disinfection;

(b) prevent maintenance of an effective disinfectant agent throughout the distribution system; and

(c) interfere with microbiological determinations.

## Section 141.15 Maximum Microbiological Contaminant Levels

(a) The supplier of water may employ one of two methods to determine compliance with the coliform maximum contaminant levels.

(1) When the supplier of water employs the membrane filter technique pursuant to sec. 141.21 (a) the coliform densities shall not exceed one per 100 milliliters as the arithmetic mean of all samples examined per month; and either

(A) four per 100 milliliters in more than one standard sample when less than 20 are examined per month; or

(B) four per 100 milliliters in more than five percent of the standard samples when 20 or more are examined per month.

(2)(A) When the supplier of water employs the fermentation tube method and 10 milliliter standard portions pursuant to sec. 141.21, coliforms shall not be present in more than 10 percent of the portions in any month; and either;

(i) three or more portions in one sample when less than 20 samples are examined per month; or

(ii) three or more portions in more than five percent of the samples if 20 or more samples are examined per month.

(B) When the supplier of water employs the fermentation tube method and 100 milliliter standard portions pursuant to sec. 141.21 (a) coliforms shall not be present in more than 60 percent of the portions in any month; and either;

(i) five or more portions in more than one sample when less than five samples are examined; or

(ii) five or more portions in more than 20 percent of the samples when five samples or more are examined.

(b) The supplier of water shall provide water in which there shall be no greater than 500 organisms per one milliliter as determined by the standard bacterial plate count provided in sec. 141.21 (f) of this subpart.

## Section 141.16 Substitution of Residual Chlorine Measurement for Total Coliform Measurement.

(a) The supplier of water may, with the approval of the State, substitute the use of chlorine residual monitoring for not more than 75% of the samples required to be taken by sec. 141.21 (b), provided that the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the frequency of at least four for each substituted microbiological sample. There shall be at least daily determinations of chlorine residual. Measurements shall be made in accordance with Standard Methods, 13th Ed., pp 129-132. When the supplier of water exercises the option provided in this paragraph (a), he shall maintain no less than 0.2 mg/l free chlorine in the public water distribution system.

(b) For public water systems serving 4900 or fewer persons, the supplier may, with the approval of the State, make a total substitution of chlorine residual measurement for the samples required to be taken by sec. 141.21 (b) provided that the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the rate of one per day for each microbiological sample required to be taken per month under sec. 141.21. When the supplier of water exercises the option provided by this paragraph (b) he shall maintain no less than 0.3 mg/l free chlorine in the public water distribution system. Measurements shall be made in accordance with Standard Methods, 13th Ed., pp 129-132.

## Section 141.21 Microbiological Contaminant Sampling and Analytical Requirements

a. The supplier of water shall make coliform density measurements, for the purpose of determining compliance with sec. 141.15, in accordance with the analytical recommendations set forth in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 13th Edition, pp 662-688, except that only a 100 milliliter sample size shall be employed in the membrane filter technique. The samples shall be taken at points which are representative of the conditions within the distribution system.

b. The supplier of water shall take coliform density samples at regular intervals throughout the month, and in number proportionate to the population served by the public water system. In no event shall the frequency be less than as set forth below:

| Population Served | Minimum Number of Samples Per Month |
|---|---|
| 25 - 2,500 | 2 |
| 2,501 - 3,300 | 3 |
| 3,301 - 4,100 | 4 |
| 4,101 - 4,900 | 5 |
| 4,901 - 5,800 | 6 |

2

| Population Served | Minimum Number of Samples Per Month |
|---|---|
| 5,801 - 6,700 | 7 |
| 6,701 - 7,600 | 8 |
| 7,601 - 8,500 | 9 |
| 8,501 - 9,400 | 10 |
| 9,401 - 10,300 | 11 |
| 10,301 - 11,100 | 12 |
| 11,101 - 12,000 | 13 |
| 12,001 - 12,900 | 14 |
| 12,901 - 13,700 | 15 |
| 13,701 - 14,600 | 16 |
| 14,601 - 15,500 | 17 |
| 15,501 - 16,300 | 18 |
| 16,301 - 17,200 | 19 |
| 17,201 - 18,100 | 20 |
| 18,101 - 18,900 | 21 |
| 18,901 - 19,800 | 22 |
| 19,801 - 20,700 | 23 |
| 20,701 - 21,500 | 24 |
| 21,501 - 22,300 | 25 |
| 22,301 - 23,200 | 26 |

| Population Served | Minimum Number of Samples Per Month |
|---|---|
| 23,201 - 24,000 | 27 |
| 24,001 - 24,900 | 28 |
| 24,901 - 25,000 | 29 |
| 25,001 - 28,000 | 30 |
| 28,001 - 33,000 | 35 |
| 33,001 - 37,000 | 40 |
| 37,001 - 41,000 | 45 |
| 41,001 - 46,000 | 50 |
| 46,001 - 50,000 | 55 |
| 50,001 - 54,000 | 60 |
| 54,001 - 59,000 | 65 |
| 59,001 - 64,000 | 70 |
| 64,001 - 70,000 | 75 |
| 70,001 - 76,000 | 80 |
| 76,001 - 83,000 | 85 |
| 83,001 - 90,000 | 90 |
| 90,001 - 96,000 | 95 |
| 96,001 - 111,000 | 100 |
| 111,001 - 130,000 | 110 |
| 130,001 - 160,000 | 120 |

4

| Population Served | Minimum Number of Samples Per Month |
|---|---|
| 160,001 - 190,000 | 130 |
| 190,001 - 220,000 | 140 |
| 220,001 - 250,000 | 150 |
| 250,001 - 290,000 | 160 |
| 290,001 - 320,000 | 170 |
| 320,001 - 360,000 | 180 |
| 360,001 - 410,000 | 190 |
| 410,001 - 450,000 | 200 |
| 450,001 - 500,000 | 210 |
| 500,001 - 550,000 | 220 |
| 550,001 - 600,000 | 230 |
| 600,001 - 660,000 | 240 |
| 660,001 - 720,000 | 250 |
| 720,001 - 780,000 | 260 |
| 780,001 - 840,000 | 270 |
| 840,001 - 910,000 | 280 |
| 910,001 - 970,000 | 290 |
| 970,001 - 1,050,000 | 300 |
| 1,050,001 - 1,140,000 | 310 |
| 1,140,001 - 1,230,000 | 320 |

| Population Served | Minimum Number of Samples Per Month |
|---|---|
| 1,230,001 - 1,320,000 | 330 |
| 1,320,001 - 1,420,000 | 340 |
| 1,420,001 - 1,520,000 | 350 |
| 1,520,001 - 1,630,000 | 360 |
| 1,630,001 - 1,730,000 | 370 |
| 1,730,001 - 1,850,000 | 380 |
| 1,850,001 - 1,970,000 | 390 |
| 1,970,001 - 2,060,000 | 400 |
| 2,060,001 - 2,270,000 | 410 |
| 2,270,001 - 2,510,000 | 420 |
| 2,510,001 - 2,750,000 | 430 |
| 2,750,001 - 3,020,000 | 440 |
| 3,020,001 - 3,320,000 | 450 |
| 3,320,001 - 3,620,000 | 460 |
| 3,620,001 - 3,960,000 | 470 |
| 3,960,001 - 4,310,000 | 480 |
| 4,310,001 - 4,690,000 | 490 |
| ≥ 4,690,001 | 500 |

**(c) (1) When the coliform colonies in a single standard sample exceed four per 100 milliliters (sec. 141.15 (a) (1) ), daily**

samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show less than one coliform per 100 milliliters.

(2) When organisms of the coliform group occur in three or more 10 ml portions of a single standard sample (sec. 141.15 (a) (2)), daily samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show no positive tubes.

(3) When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample (Sec. 141.15 (3)), daily samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show no positive tubes.

(4) The location at which the check sample was taken pursuant to subparagraphs (1), (2) or (3) must not be eliminated from future sampling because of a history of questionable water quality. Check samples shall not be included in calculating the total number of samples taken each month to determine compliance with sec. 141.15.

(d) When a particular sampling point has been confirmed, by the first check sample examined as directed in paragraph (c)(1), (2) or (3), to be in non-compliance with the maximum contaminant levels set forth in section 141.15, the supplier of water shall notify the State as prescribed in sec. 141.31.

(e) When the maximum contaminant levels set forth in subparagraphs (1) or (2) of Section 141.15 (a) are exceeded as confirmed by check samples taken pursuant to paragraph (c) (1), (2) or (3), the supplier of water shall report as directed in Sec. 141.32 (a).

(f) When a particular sampling point has been shown to be in non-compliance with the requirements of sec. 141.16, water from that location shall be retested within one hour. If the non-compliance is confirmed, the State shall be notified as prescribed in sec. 141.31. Also, if the non-compliance is confirmed, a sample for coliform analysis must be immediately collected from that sampling point and the results of such analysis reported to the State.

(g) Standard bacteria plate count samples shall be analyzed in accordance with the recommendation set forth in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 13th Edition, pp 660-662. Samples taken for the purpose of plate count analysis shall be collected at points which are representative of conditions within the distribution system at a frequency at least equal to 10% of the frequency for coliform analysis as directed in paragraph (b), with the exception that at least one sample shall be collected and analyzed monthly.

## Sec. 141.22 Turbidity Sampling and Analytical Requirements

(a) Samples shall be taken at a representative entry point (s) to the water distribution system at least once per day, (at least once per month for supplies using water obtained from underground sources) for the purpose of making turbidity measurements to determine compliance with Sec. 141.14. The measurement shall be made in accordance with the recommendations set forth in Standard Methods for the Examination of Water and Wastewater, American Public Health Association, 13th Edition, pp. 350-353 (Nephelometric Method).

(b) In the event that such measurement indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be repeated within one hour. The results of the two measurements shall be averaged, and if the average confirms that the maximum allowable limit has been exceeded, this average shall be reported as directed in Sec. 141.31. If the monthly average of all samples exceeds the maximum allowable limit, this fact shall be reported as directed in sec. 141.32(a).

(c) The requirements of this sec. 141.22 shall not apply to public water systems other than community water systems which use water obtained from underground sources.

## Sec. 141.23 Inorganic Chemical Sampling and Analytical Requirements

(a)(1) To establish an initial record of water quality, an analysis of substances for the purpose of determining compliance with sec. 141.11 shall be completed for all community water systems utilizing surface water sources within one year following the effective date of this sub-part. This analysis shall be repeated at yearly intervals.

(2) An analysis for community water systems utilizing ground water sources shall be completed within two years following the effective date of this sub-part. This analysis shall be repeated at three-year intervals.

(3) Analyses for public water systems other than community water systems, whether supplied by surface or ground water sources, shall be completed within six years following the effective date of this sub-part. These analyses shall be repeated at five-year intervals.

(b) If the supplier of water determines or has been informed by the State that the level of any contaminant is 75% or more of the maximum contaminant level, he shall analyze for the presence and quantity of that contaminant at least once per month following the initial analysis or information. If, after conducting monthly testing for a period of at least one year, the supplier of water demonstrates to the satisfaction of the State that the level of such contaminant is stable and due to a natural condition of the water source, he may reduce the frequency of analysis for that contaminant consistent with the requirements of paragraph (a) of this section.

(c) If the supplier of water determines or has been informed by the State that the level of any contaminant listed in sec. 141.11 exceeds the maximum contaminant level for the substance, he shall confirm such determination or information by repeating the analysis within 24 hours following the initial analysis or information, and then at least at weekly intervals during the period of time the maximum contaminant level for that substance has been exceeded, or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective. The results of such repetitive testing shall be averaged and reported as prescribed in paragraph (d).

(d) To judge the compliance of a public water system with the maximum contaminant levels listed in sec. 141.11, averages of data shall be used and shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question. Each average shall be calculated on a past 12-month moving average basis if less than twelve samples per year are analyzed, and on a past three month moving average basis if twelve or more samples per year are analyzed. In cases where the maximum contaminant level has been exceeded in any one sample, the average concentration shall be calculated on a one-month moving average basis and reported pursuant to sec. 141.31. If the mean of the samples comprising the one month moving average exceeds the maximum contaminant level, the supplier of water shall give public notice pursuant to sec. 141.32(a).

(e) The provisions of paragraphs (c) and (d) notwithstanding, compliance with the maximum contaminant level for nitrate shall be determined on the basis of individual analyses rather than by averages. When a level exceeding the maximum contaminant level for nitrate is found, the analyses shall be repeated within 24 hours, and if the mean of the two analyses exceeds the maximum contaminant level, the supplier of water shall report his findings pursuant to sections 141.31 and 141.32 (a).

(f) Analyses conducted to determine compliance with sec. 141.11 shall be made in accordance with the following methods:

(1) Arsenic - Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, pp. 95-95, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(2) Barium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 97-98, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(3) Cadmium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp.210-215, or Methods for Chemical Analysis of Water and Wastes, pp 101-103, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(4) Chromium - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition,

pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 105-106, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(5) Cyanide-Titration or Colorimetric Methods, Methods for Chemical Analysis of Water and Wastes, pp 40-48, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(6) Lead-Atomic Absorption Method, Standards Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, pp 112-113, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(7) Mercury-Flameless Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, pp 118-126, Environmental Protection Agency, Office of Technology Transfer Washington, D.C. 20460, 1974.

(8) Nitrate - Brucine Colormetric Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 461-464, or Cadmium Reduction Method, Methods for Chemical Analysis of Water and Wastes, pp 201-206, Environmental

Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(9) Selenium - Atomic Absorption Method, Methods for Chemical Analysis of Water and Wastes, p. 145, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(10) Silver - Atomic Absorption Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 210-215, or Methods for Chemical Analysis of Water and Wastes, p 146, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(11) Fluoride - Electrode Method, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 172-174, or Methods for Chemical Analysis of Water and Wastes, pp 65-67; Environmental Protection Agency, Office of Technology Transfer, Washington, D.C., 20460, 1974, or Colorimetric Method with Preliminary Distillation, Standard Methods for the Examination of Water and Wastewater, 13th Edition, pp 171-172 and 174-176, or Methods for Chemical Analysis of Water and Wastes, pp 59-60, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

## Sec. 141.24 Pesticide and Organic Chemicals Sampling and Analytical Requirements

(a) (1) To establish an initial record of water quality, an analysis of substances for the purpose of determining compliance with sections 141.12 and 141.13 shall be completed for all community water systems utilizing surface water sources within one year following the effective date of this sub-part. This analysis shall be repeated at yearly intervals.

(2) An analysis for community water systems utilizing ground water sources shall be completed within two years following the effective date of this sub-part. This analysis shall be repeated at three-year intervals.

(3) Analyses for public water systems other than community water systems, whether supplied by surface or ground water sources, shall be completed within six years following the effective date of this sub-part. These analyses shall be repeated at five-year intervals.

(b) If the supplier of water determines or has been informed by the State that the level of any contaminant is 75% or more or the maximum contaminant level, he shall analyze for the presence and quantity of that contaminant at least once per month following the initial analysis or information. If, after conducting monthly testing for a period of at least one year, the supplier of water demonstrates to the satisfaction of the State that the level of such contaminant is stable and due to a natural condition of the water source, he may reduce the frequency of analysis for that contaminant consistent with the requirements of paragraph (a) of this section.

(c) If the supplier of water determines or has been informed by the State that the level of contaminants set forth in sec. 141.12 exceeds the maximum contaminant level, he shall confirm such determination or information be repeating the analyses within two weeks following the initial analysis or information. The average of the two analyses, if in excess of the maximum contaminant level, shall be reported as directed in sec. 141.31 and 141.32 (a).

(d) If the supplier of water determines or has been informed by the State that the level of any contaminant listed in sec. 141.13 exceeds the maximum contaminant level for the substance, he shall confirm such determination or information by repeating the analysis within 24 hours following the initial analysis or information, and then at least at weekly intervals during the period of time the maximum contaminant level for that substance has been exceeded, or until a monitoring schedule as a condition to variance, exemption or enforcement action shall become effective. The results of such repetitive testing shall be averaged and reported as prescribed in paragraph (e).

(e) To judge the compliance of a public water system with the maximum contaminant levels listed in section 141.13, averages of data shall be used and shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question. Each average shall be calculated on a past 12-month moving average basis if less than twelve samples per year are analyzed, and on a past three month moving average basis if twelve or more samples per year are analyzed. In cases where the maximum contaminant levels of sec. 141.13 have been exceeded in any one sample, the average concentration shall be calculated on a one-month moving average basis and reported pursuant to sec. 141.31. If the mean of the samples comprising the one month moving average exceeds the maximum contaminant level, the supplier of water shall give public notice pursuant to sec. 141.32 (a).

(f) Sampling and analyses made to determine compliance with sec. 141.12 shall be made in accordance with An Improved Method for Determining Organics in Water by Activated Carbon Absorption and Solvent Extraction, Parts 1 and 2, Buelow, et. al., Journal of American Water Works Association, 65: 57, 197 (1973).

(g) Analyses made to determine compliance with sec. 141.13(a) shall be made in accordance with Method for Organochlorine Pesticides in Industrial Effluents, MDQARL, Environmental Protection Agency, Cincinnati, Ohio Nov. 28, 1973.

(h) Analyses made to determine compliance with sec. 141.13(b) shall be conducted in accordance with Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents, MDQARL, Cincinnati, Ohio, Nov 23, 1973.

## Sec. 141.27 Laboratory Certification

For the purposes of determining compliance with secs. 141.21 through 141.24, samples may be considered only if they have been analyzed by a laboratory approved by the State. The approval shall be contingent upon maintenance of proper laboratory methods and technical competence and upon the retention for inspection at reasonable times of analytical results. Approved laboratories shall make periodic reports as required by the State.

## Sec. 141.31 Reporting Requirements

The supplier of water shall report within 40 days following a test, measurement or analysis required to be made by this subpart, the results of that test, measurement or analysis, provided that the supplier of water shall report within 36 hours the failure to meet any standards (including failure to comply with monitoring requirements) set forth in this subpart. Reports required to be made by this section 141.31 shall be communicated to the State, except that Federal Agencies shall report to the Regional Administrator.

## Sec. 141.32 Public Notification of Variances, Exemptions and Noncompliance with Standards

(a) The supplier of water shall give notice to the persons served by the public water system of any failure on the part of the system to comply with the requirements (including monitoring requirements) of this subpart. The supplier of water shall give the notice required by this section 141.32 not less than once every three months during the life of the noncompliance:

(1) by publication on not less than three consecutive days in a newspaper or newspapers of general circulation serving the area served by such public water system, which newspaper or newspapers shall be approved by the State. With respect to the public water systems operated by Federal Agencies, the newspapers cited in this paragraph shall be approved by the Regional Administrator;

(2) by furnishing a copy thereof to the radio and television stations serving such area as soon as practicable but not later than 36 hours after confirmation of the noncompliance with respect to which the notice is required; and

(3) by inclusion with the water bills of the public water system at least once every three months if the water bills are issued at least once every three months, and with every water

bill if they are issued less often. If water bills are not issued, other means of notification acceptable to the State may be used.

The notice required by this sec. 141.32 shall state at least that the public water system fails to monitor, operate the system or provide water which meets all the requirements of this Part 141, Subpart A, and shall state with particularity those requirements for which there is noncompliance. If a quantitive limitation has been exceeded, the notice shall state what the federal or State limitation is, and at what level of performance the water supply system has been operating.

(b) The supplier of water shall give notice pursuant to the procedures set forth in paragraph (a) -

(1) when his system has received a variance under sec. 1415 (a) (1) or 1415 (a) (2) of the Act, and shall continue the notification process at no less than three month intervals during the life of the variance;

(2) when his system has received an exemption under sec. 1416 and shall continue the notification process at no less than three month intervals during the life of the exemption; or

(3) when his system has failed to comply with any schedule

or control measure prescribed pursuant to a variance or exemption and shall continue the notification process at no less than the three month intervals during the life of the variance and exemption.

## Section 141.41 Siting Requirements

Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall -

(a) to the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(1) is subject to earthquakes, floods, fires or other man-made disasters which could cause breakdown of the public water system or a portion thereof; and

(2) is within the floodplain of a 100 year flood;

(b) Notify the State.

## Section 141.51 Effective Date

The standards set forth in this subpart A of Part 141 shall take effect 18 months after the date of promulgation.

# APPENDIX B

## QUESTIONNAIRE TO STATE AGENCIES WITH RESPONSIBILITY FOR DRINKING WATER STANDARDS

Name and Address of Agency:

______________________________

______________________________

______________________________ Person(s) Filling Out Questionnaire

______________________________ ______________________________

______________________________ ______________________________

1. LABORATORY CERTIFICATION

a. Does the state have a program for certification of analytical laboratories which monitor the inorganic quality of drinking water?

1) Local water system in-house labs? YES____ NO____

2) Private commercial labs? YES____ NO____

3) Municipal labs not operated by water depts? YES____ NO____

4) State labs? YES____ NO____

How many certified labs are there in each category?

In-house_______ Private_______ Municipal_______ State_______

Could you please attach a list of such laboratories?

b. Does the state have a program for certification of analytical laboratories to monitor the organic and pesticide quality of drinking water?

1) Local water system in-house labs? YES____ NO____

2) Private commercial labs? YES____ NO____

3) Municipal labs not operated by water depts? YES____ NO____

4) State labs? YES____ NO____

How many certified labs are there in each category?

In-House______ Private______ Municipal______ State______

Could you please attach a list of such laboratories?

c. Does the state have a program for certification of analytical laboratories to monitor the bacteriological quality of drinking water?

1) Local water system in-house labs? YES____ NO____

2) Private commercial labs? YES____ NO____

3) Municipal labs not operated by water depts? YES____ NO____

4) State labs? YES____ NO____

How many certified labs are there in each category?

In-House_______ Private_______ Municipal_______ State_______

Could you please attach a list of such laboratories?

d. Does the state certify individual water system to monitor turbidity (yes/no) and residual chlorine (yes/no)? How many?

Turbidity________ Residual Chlorine________

2. MONITORING

a. Who performs water quality analyses?
(Answer with percents of total task work.)

| | TYPE OF LABORATORY | | | | |
|---|---|---|---|---|---|
| | In-House | Private Commercial | Municipal | State | TOTAL |
| Sample Collection | | | | | 100 |
| Inorganic Analyses | | | | | 100 |
| Organic Analyses | | | | | 100 |
| Pesticide Analyses | | | | | 100 |
| Coliform Analyses | | | | | 100 |
| Plate Count Analyses | | | | | 100 |
| Turbidity Analyses | | | | | 100 |
| Residual Chlorine | | | | | 100 |
| Radiological Analyses | | | | | 100 |

b. Must performing labs be certified? YES____ NO____

c. Please supply data on the numbers of different types of drinking water systems within the state:

1) Number of systems drawing on surface water sources[a] and serving communitites[b] ___________.

2) Number of systems drawing only on ground water sources[c] and serving communities[b] ___________.

3) Number of systems drawing on surface water sources[a] and serving only transients[d] ___________.

4) Number of systems drawing only on ground water sources[c] and serving only transients ___________.

5) Number of systems drawing only on suppliers of finished water ___________.

d. Does the state have standards for the frequency of monitoring for: (If no requirement, answer "No")

| | Community Systems | | |
|---|---|---|---|
| | Surface Water | Ground Water | Transient Systems |
| Inorganics | Every _____ Years | Every _____ Years | Every _____ Years |
| Organics | Every _____ Years | Every _____ Years | Every _____ Years |
| Pesticides | Every _____ Years | Every _____ Years | Every _____ Years |
| Coliform | _______ Samples per mo. | _______ Samples per mo. | _______ Samples per mo. |
| Plate Count | _______ " | _______ " | _______ " |
| Turbidity | _______ " | _______ " | _______ " |

[a] May be supplemented by ground and finished waters.

[b] 25 or more permanent residents.

[c] May be supplemented by finished waters.

[d] Average of 25 or more in any three month period.

e. Please supply data on the work load of state laboratories performing water quality analyses:

| Contaminant | How Many Samples Are Presently Analyzed Each Year? | How Many Samples Could Be Analyzed with Present Facilities and Manpower? |
|---|---|---|
| Inorganics | | |
| Organics | | |
| Pesticides | | |
| Coliform | | |
| Plate Count | | |
| Turbidity | | |
| Radiological | | |

f. Who pays for monitoring costs? (Answer with percentage of total costs)

1) Local Water Systems? ______

2) Municipal Agency? ______

3) State Agency? ______

g. If state laboratory does drinking water quality analyses, can you supply us with cost data for these analyses? (Annual Basis)

1) Direct Labor ____________

2) Supplies and Equipment ____________

3) Overhead ____________

4) Total Cost ____________

5) Number of Personnel (full time equivalent) ____________

3. ENFORCEMENT

a. Does the state enforce any standards for maximum contaminant levels in drinking water? YES____ NO____

b. If YES, do these standards conform to the 1962 PHS Drinking Water Standards? YES____ NO____

c. If enforced standards are substantially different from the 1962 PHS Standards, please describe the state standards:

________________________________________________

________________________________________________

________________________________________________

________________________________________________

d. How many inspectors does the state employ in its enforcement programs? ____________

e. What actions, if any, are taken against systems which violate standards? ________________________________

________________________________________________

________________________________________________

f. Please name the state agencies, if any, responsible for:

1) Enforcement of standards ________________________

________________________________________________

2) Recorder of violations ________________________

________________________________________________

4. SAFE DRINKING WATER ACT

The latest draft of the Proposed Interim Primary Standards calls for the following frequencies of monitoring

| | TYPE OF SYSTEM | | | |
|---|---|---|---|---|
| | Community | | Transient | |
| Inorganics, Organics and Pesticides | Annually | Every 3 Years | Every 6 Years | Every 6 Years |
| Turbidity | Daily | Monthly | Daily | None |
| Coliform | 2 to 500 Samples Per Month Based on Number of Customers Served* | | | |
| Plate Count | 1 to 500 Samples Per Month Based on Number of Customers Served | | | |

*1962 PHS, Recommended Sampling Frequencies.

a. Do you anticipate any difficulties with this level of monitoring in terms of the availability of analytical facilities? (If so, please describe) ______________________

______________________________________________

______________________________________________

b. Do you anticipate any diffficulties in funding this level of monitoring? (If so, please describe) ______________________

______________________________________________

______________________________________________

5. Does the state issue permits for construction of water supply systems? YES____ NO____

6. Does the state issue permits for construction of additional facilities at existing water supply systems? YES____ NO____

7. Does your state plan to encourage the use of residual chlorine monitoring to replace and/or supplement coliform density measurements? YES____ NO____

8. Please add any additional comments.

## TABLE B-1

## PERCENT OF INORGANIC ANALYSES DONE BY FOUR AGENCIES BY STATE

|  | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA |  |  |  |  |
| ALASKA | 20 | 40 | 20 | 20 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS |  |  |  |  |
| CALIFORNIA | N | N | N | N |
| COLORADO | 20 | 20 | 0 | 60 |
| CONNECTICUT | N | N | N | N |
| DELAWARE |  |  |  |  |
| DISTRICT OF COLUMBIA |  |  |  |  |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 60 | 0 | 0 | 40 |
| IDAHO | 0 | 0 | 0 | 100 |
| ILLINOIS |  |  |  |  |
| INDIANA | 75 | 0 | 1 | 24 |
| IOWA | N | N | N | 99 |
| KANSAS | 0 | 0 | 0 | 100 |
| KENTUCKY | 10 | 0 | 0 | 90 |
| LOUISIANA |  |  |  |  |
| MAINE | 10 | N | N | 90 |
| MARYLAND |  |  |  |  |
| MASSACHUSETTS |  |  |  |  |
| MICHIGAN | 0 | 0 | 0 | 100 |
| MINNESOTA |  |  |  |  |
| MISSISSIPPI |  |  |  |  |
| MISSOURI |  |  |  |  |
| MONTANA | N | N | N | N |
| NEBRASKA | 0 | 0 | 0 | 100 |
| NEVADA |  |  |  |  |
| NEW HAMPSHIRE |  |  |  |  |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 10 | 0 | 90 |
| NEW YORK | N | N | N | N |
| NORTH CAROLINA | 10 | 0 | 0 | 90 |
| NORTH DAKOTA | 10 | 0 | 1 | 90 |
| OHIO | 10 | 0 | 0 | 90 |
| OKLAHOMA |  |  |  |  |
| OREGON |  |  |  |  |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 50 | 1 | 0 | 50 |
| SOUTH DAKOTA |  |  |  |  |
| TENNESSEE |  |  |  |  |
| TEXAS | 1 | 2 | 0 | 97 |
| UTAH | 0 | 30 | 0 | 70 |
| VERMONT | 0 | 0 | 0 | 100 |
| VIRGINIA | 0 | 0 | 0 | 100 |
| WASHINGTON | 0 | 100 | 0 | 90 |
| WEST VIRGINIA | 0 | 0 | 0 | 90 |
| WISCONSIN |  |  |  |  |
| WYOMING | 0 | 0 | 0 | 100 |

N is not known.
No entry indicates lack of response.

## TABLE B-2

## STATE LAB WORK LOAD (INORGANICS)

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | few hundred | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | 1,666 | 1,666 |
| COLORADO | 550 | 550 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 9,000 | 9,000 |
| HAWAII | 669 | 1,000 |
| IDAHO | 214 | 250 |
| ILLINOIS | | |
| INDIANA | 16,620 | 17,000 |
| IOWA | 700-900 | N |
| KANSAS | 300 | 1,500 |
| KENTUCKY | 546 (partial) 8 (total) | 600 (partial) 10 (total) |
| LOUISIANA | | |
| MAINE | 500 | +25%+ |
| MARYLAND | | |
| MASSACHUSETTS | | |
| MICHIGAN | 13 (plus 144 mercury only) | 13 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 300 | 1,500 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 7,000 | 7,700 |
| NEW YORK | N | N |
| NORTH CAROLINA | 4,000 | 4,000 |
| NORTH DAKOTA | 3,000 | +20% |
| OHIO | 1,646 | 2,000 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | 2,609 | N |
| RHODE ISLAND | 592 | N |
| SOUTH CAROLINA | 2,200 | 2,500 |
| SOUTH DAKOTA | 5,500 | 6,500 |
| TENNESSEE | | |
| TEXAS | 3,325 | 3,500 |
| UTAH | 2,000 | 3,000 |
| VERMONT | 4,000 | 4,000 |
| VIRGINIA | 728 | N |
| WASHINGTON | 2,500 | 2,500 |
| WEST VIRGINIA | 1,000 | 1,000 |
| WISCONSIN | | |
| WYOMING | 60 | 220 |

N is not known.
No entry indicates lack of response.

# TABLE B-3

## PERCENT OF ORGANIC ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 5 | 90 | 0 | 5 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 10 | 10 | 0 | 80 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 100 | 0 | 0 | 0 |
| IDAHO | N | N | N | N |
| ILLINOIS | | | | |
| INDIANA | 1 | N | 0 | 99 |
| IOWA | N | 0 | 0 | 99 |
| KANSAS | 100 | 0 | 0 | 0 |
| KENTUCKY | 0 | 0 | 0 | 100 |
| LOUISIANA | | | | |
| MAINE | N | N | N | N |
| MARYLAND | | | | |
| MASSACHUSETTS | | | | |
| MICHIGAN | 0 | 0 | 0 | 100 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 100 | 0 | 0 | 0 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | N | N | N | N |
| NEW YORK | N | N | | |
| NORTH CAROLINA | 10 | 0 | 0 | 90 |
| NORTH DAKOTA | 95 | 0 | 0 | 100 |
| OHIO | 0 | 0 | 0 | 0 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 0 | 0 | 0 | 100 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 0 | 0 | 0 | 0 |
| UTAH | 0 | 0 | 0 | 100 |
| VERMONT | 0 | 0 | 0 | 0 |
| VIRGINIA | 0 | 0 | 0 | 100 |
| WASHINGTON | | | | |
| WEST VIRGINIA | 0 | 0 | 0 | 90 |
| WISCONSIN | | | | |
| WYOMING | 0 | 100 | 0 | 0 |

N is not known.
No entry indicates lack of response.

# TABLE B-4

## STATE LAB WORK LOAD (ORGANICS)

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | Few | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | 1,666 | 1,666 |
| COLORADO | 550 | 550 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 0 |
| HAWAII | 0 | 0 |
| IDAHO | 214 | 250 |
| ILLINOIS | | |
| INDIANA | 38 | 40 |
| IOWA | 700-900 | N |
| KANSAS | 0 | 0 |
| KENTUCKY | 75 | N |
| LOUISIANA | N | N |
| MAINE | | |
| MARYLAND | | |
| MASSACHUSETTS | | |
| MICHIGAN | 13 | 13 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | 0 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 0 | 0 |
| NEW YORK | N | N |
| NORTH CAROLINA | 100 | 100 |
| NORTH DAKOTA | N | N |
| OHIO | 0 | 0 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | N | N |
| SOUTH CAROLINA | 175 | 175 |
| SOUTH DAKOTA | N | N |
| TENNESSEE | | |
| TEXAS | 0 | 0 |
| UTAH | N | N |
| VERMONT | 0 | 0 |
| VIRGINIA | 30 | N |
| WASHINGTON | 0 | 0 |
| WEST VIRGINIA | 10 | 20 |
| WISCONSIN | | |
| WYOMING | 0 | 0 |

N is not known.
No entry indicates lack of response.

# TABLE B-5

## PERCENT OF PESTICIDE ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 0 | 50 | N | 50 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 5 | 5 | 0 | 90 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 90 | 0 | 0 | 100 |
| IDAHO | 0 | 0 | 0 | 100 |
| ILLINOIS | | | | |
| INDIANA | 0 | 0 | 0 | 100 |
| IOWA | N | N | N | 99 |
| KANSAS | 100 | 0 | 0 | 0 |
| KENTUCKY | 0 | 0 | 0 | 100 |
| LOUISIANA | N | N | N | N |
| MAINE | | | | |
| MARYLAND | | | | |
| MASSACHUSETTS | | | | |
| MICHIGAN | 0 | 0 | 0 | 100 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 100 | 0 | 0 | 0 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 0 | 0 | 100 |
| NEW YORK | N | N | | |
| NORTH CAROLINA | 10 | 0 | 0 | 90 |
| NORTH DAKOTA | 0 | N | 0 | 100 |
| OHIO | 0 | 0 | 0 | 100 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 0 | 0 | 0 | 100 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 1 | 0 | 0 | 99 |
| UTAH | 0 | 0 | 0 | 100 |
| VERMONT | 0 | 0 | 0 | 0 |
| VIRGINIA | 0 | 0 | 0 | 100 |
| WASHINGTON | 0 | 0 | 0 | 100 |
| WEST VIRGINIA | 0 | 0 | 0 | 20 |
| WISCONSIN | | | | |
| WYOMING | 0 | 100 | 0 | 0 |

N is not known.
No entry indicates lack of response.

# TABLE B-6

## STATE LAB WORK LOAD PESTICIDES

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | 0 | N |
| ARIZONA | N | N |
| ARKANSAS | 1,666 | 1,666 |
| CALIFORNIA | 0 | 0 |
| COLORADO | N | N |
| CONNECTICUT | | |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 0 |
| HAWAII | 16 | 16 |
| IDAHO | 167 | 200 |
| ILLINOIS | | |
| INDIANA | 0 | 10 |
| IOWA | 700-900 | N |
| KANSAS | 0 | 0 |
| KENTUCKY | 20 | 200 |
| LOUISIANA | | |
| MAINE | N | N |
| MARYLAND | | |
| MASSACHUSETTS | | |
| MICHIGAN | 13 | 13 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | 0 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 200 | 300 |
| NEW YORK | N | N |
| NORTH CAROLINA | under 50 | under 50 |
| NORTH DAKOTA | 0 | 0 |
| OHIO | 300 | 300 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | 184 | N |
| SOUTH CAROLINA | 175 | 175 |
| SOUTH DAKOTA | N | N |
| TENNESSEE | | |
| TEXAS | 100 | 100 |
| UTAH | 20 | 20 |
| VERMONT | 0 | 0 |
| VIRGINIA | 30 | N |
| WASHINGTON | N | N |
| WEST VIRGINIA | 20 | 20 |
| WISCONSIN | | |
| WYOMING | 0 | 0 |

N is not known.
No entry indicates lack of response.

## TABLE B-7

## PERCENT OF COLIFORM ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 0 | 10 | N | 90 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 30 | 1 | 1 | 49 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 10 | 90 |
| HAWAII | 60 | 0 | 0 | 40 |
| IDAHO | 0 | 2 | 0 | 98 |
| ILLINOIS | | | | |
| INDIANA | 15 | 0 | 5 | 80 |
| IOWA | 0 | 5 | 45 | 50 |
| KANSAS | 20 | 0 | 10 | 70 |
| KENTUCKY | 20 | 0 | 10 | 70 |
| LOUISIANA | | | | |
| MAINE | 10 | 0 | 0 | 90 |
| MARYLAND | | | | |
| MASSACHUSETTS | N | N | N | N |
| MICHIGAN | 82 | 0 | 0 | 18 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 20 | 0 | 10 | 70 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 0 | 0 | 100 |
| NEW YORK | N | N | | |
| NORTH CAROLINA | 25 | 0 | 0 | 75 |
| NORTH DAKOTA | 10 | 0 | 1 | 90 |
| OHIO | 10 | 0 | 0 | 90 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 68 | 1 | N | 32 |
| SOUTH DAKOTA | 0 | 0 | 10 | 90 |
| TENNESSEE | | | | |
| TEXAS | 10 | 0 | 0 | 90 |
| UTAH | 25 | 2 | 13 | 60 |
| VERMONT | 0 | 0 | 0 | 100 |
| VIRGINIA | 25 | 0 | 0 | 80 |
| WASHINGTON | 10 | 0 | 50 | 40 |
| WEST VIRGINIA | 0 | 5 | 25 | 70 |
| WISCONSIN | | | | |
| WYOMING | 1 | 0 | 0 | 99 |

N is not known.

No entry indicates lack of response.

# TABLE B-8

## STATE LAB WORK LOAD COLIFORM

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | 20,000 | N |
| ARIZONA | N | N |
| ARKANSAS | 15,000 | 15,000 |
| CALIFORNIA | 9,800 | 9,800 |
| COLORADO | N | N |
| CONNECTICUT | | |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 40,000 | 40,000 |
| HAWAII | 5,953 | 6,000 |
| IDAHO | 7,191 | 10,000 |
| ILLINOIS | | |
| INDIANA | 25,648 | 26,000 |
| IOWA | 40,000 | N |
| KANSAS | N | N |
| KENTUCKY | 21,000 | 21,000 |
| LOUISIANA | | |
| MAINE | 10,000 | 12,500 |
| MARYLAND | | |
| MASSACHUSETTS | N | N |
| MICHIGAN | 24,000 | 24,000 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | 0 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 25,000 | 25,000 |
| NEW YORK | N | N |
| NORTH CAROLINA | 40,000 | 40,000 |
| NORTH DAKOTA | 7,000 | N |
| OHIO | 45,000 | 45,000 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | 2,609 | N |
| RHODE ISLAND | 6,870 | N |
| SOUTH CAROLINA | 50,000 | 70,000 |
| SOUTH DAKOTA | 15,000 | 17,000 |
| TENNESSEE | | |
| TEXAS | 260,322 | 275,000 |
| UTAH | 20,000 | 40,000 |
| VERMONT | 20,000 | 20,000 |
| VIRGINIA | 84,520 | N |
| WASHINGTON | 15,000 | 15,000 |
| WEST VIRGINIA | N | N |
| WISCONSIN | | |
| WYOMING | 7,575 | 10,000 |

N is not known.
No entry indicates lack of response.

## TABLE B-9

## PERCENT OF PLATE COUNT ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 0 | 10 | 0 | 90 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | N | N | N | N |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 60 | 0 | 0 | 40 |
| IDAHO | 1 | | | |
| ILLINOIS | | | | |
| INDIANA | 5 | 0 | 0 | 95 |
| IOWA | 0 | 0 | 10 | 90 |
| KANSAS | 20 | 0 | 10 | 70 |
| KENTUCKY | 100 | 0 | 0 | 0 |
| LOUISIANA | | | | |
| MAINE | 0 | 0 | 0 | 100 |
| MARYLAND | | | | |
| MASSACHUSETTS | N | N | N | N |
| MICHIGAN | 100 | 0 | 0 | 0 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 20 | 0 | 10 | 70 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 0 | 0 | 100 |
| NEW YORK | N | N | N | N |
| NORTH CAROLINA | N | N | N | N |
| NORTH DAKOTA | 10 | 0 | 1 | 90 |
| OHIO | 0 | 0 | 0 | 0 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 5 | N | N | 95 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 0 | 0 | 0 | 100 |
| UTAH | 30 | 0 | 10 | 60 |
| VERMONT | 0 | 0 | 0 | 0 |
| VIRGINIA | 85 | 0 | 0 | 15 |
| WASHINGTON | | | | |
| WEST VIRGINIA | 0 | 0 | 0 | 100 |
| WISCONSIN | | | | |
| WYOMING | 0 | 100 | 0 | 0 |

N is not known.
No entry indicates lack of response.

## TABLE B-10

## STATE LAB WORK LOAD PLATE COUNT

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | several hundred | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | 15,000 | 15,000 |
| COLORADO | 0 | 0 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 0 |
| HAWAII | 1,000 | 1,000 |
| IDAHO | 0 | N |
| ILLINOIS | | |
| INDIANA | 0 | 0 |
| IOWA | 0 | 0 |
| KANSAS | 16,000 | 16,000 |
| KENTUCKY | 0 | 0 |
| LOUISIANA | | |
| MAINE | 400 | 25% |
| MARYLAND | | |
| MASSACHUSETTS | N | N |
| MICHIGAN | few | few |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 16,000 | 16,000 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 45 | 2,500 |
| NEW YORK | N | N |
| NORTH CAROLINA | 0 | N |
| NORTH DAKOTA | 0 | |
| OHIO | 10 | N |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | 1,480 | N |
| SOUTH CAROLINA | 3,000 | 5,000 |
| SOUTH DAKOTA | N | N |
| TENNESSEE | | |
| TEXAS | 50 | 300 |
| UTAH | 2,600 | 3,000 |
| VERMONT | not routinely analyzed | |
| VIRGINIA | 42 | N |
| WASHINGTON | 0 | 0 |
| WEST VIRGINIA | N | N |
| WISCONSIN | | |
| WYOMING | 0 | 0 |

N is not known.
No entry indicates lack of response.

## TABLE B-11

## PERCENT OF TURBIDITY ANALYIS DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 30 | 50 | 10 | 10 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 90 | 0 | N | 9 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 60 | 0 | 0 | 40 |
| IDAHO | | | | |
| ILLINOIS | | | | |
| INDIANA | 95 | 0 | 1 | 4 |
| IOWA | 0 | 0 | 20 | 80 |
| KANSAS | 100 | 0 | 0 | 0 |
| KENTUCKY | 50 | 0 | 0 | 50 |
| LOUISIANA | | | | |
| MAINE | 20 | 0 | 0 | 80 |
| MARYLAND | | | | |
| MASSACHUSETTS | N | N | N | N |
| MICHIGAN | 99 | 0 | 0 | 1 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 100 | 0 | 0 | 0 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 0 | 95 | 5 |
| NEW YORK | 100 | 0 | 0 | 0 |
| NORTH CAROLINA | 10 | 0 | 0 | 90 |
| NORTH DAKOTA | 1 | 0 | 1 | 95 |
| OHIO | 5 | 0 | 0 | 95 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 92 | 0 | 0 | 8 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 100 | 0 | 0 | 0 |
| UTAH | 0 | 0 | 50 | 50 |
| VERMONT | 0 | 0 | 0 | 100 |
| VIRGINIA | 100 | 0 | 0 | 0 |
| WASHINGTON | 50 | 0 | 0 | 50 |
| WEST VIRGINIA | 0 | 0 | 0 | 60 |
| WISCONSIN | | | | |
| WYOMING | 95 | 0 | 0 | 5 |

N is not known.
No entry indicates lack of response.

# TABLE B-12

## STATE LAB WORK LOAD TURBIDITY

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | few | N |
| ARIZONA | N | N |
| ARKANSAS | | |
| CALIFORNIA | N | N |
| COLORADO | 500 | 500 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 0 |
| HAWAII | 250 | 500 |
| IDAHO | N | N |
| ILLINOIS | | |
| INDIANA | 388 | 500 |
| IOWA | 700-900 | N |
| KANSAS | 0 | 1,500 |
| KENTUCKY | 546 | 600 |
| LOUISIANA | | |
| MAINE | 400 | +25%+ |
| MARYLAND | | |
| MASSACHUSETTS | N | N |
| MICHIGAN | 450 | 450 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | 1,500 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | Unknown N | Unknown N |
| NEW MEXICO | 6,000 | 6,600 |
| NEW YORK | N | N |
| NORTH CAROLINA | 4,000 | 4,000 |
| NORTH DAKOTA | 0 | N |
| OHIO | 1,646 | 2,000 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | 1,120 | N |
| SOUTH CAROLINA | 2,200 | 3,000 |
| SOUTH DAKOTA | N | N |
| TENNESSEE | | |
| TEXAS | 0 | 100 |
| UTAH | 2,000 | 3,000 |
| VERMONT | 4,000 | 4,000 |
| VIRGINIA | 728 | N |
| WASHINGTON | W/Inorganics figure | W/Inorganics figure |
| WEST VIRGINIA | 500 | 500 |
| WISCONSIN | | |
| WYOMING | 0 | 0 |

N is not known.
No entry indicates lack of response.

TABLE B-13

## PERCENT OF RADIOLOGICAL ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 0 | 100 | 0 | 0 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 0 | 2 | 0 | 98 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 0 | 0 | 0 | 0 |
| IDAHO | | | | |
| ILLINOIS | | | | |
| INDIANA | 0 | 0 | 0 | 100 |
| IOWA | 0 | 0 | 1 | 99 |
| KANSAS | 100 | 0 | 0 | 0 |
| KENTUCKY | 0 | 0 | 0 | 100 |
| LOUISIANA | | | | |
| MAINE | 0 | 0 | 0 | 0 |
| MARYLAND | | | | |
| MASSACHUSETTS | N | N | N | N |
| MICHIGAN | 0 | 0 | 0 | 100 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 100 | 0 | 0 | 0 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 100 | 0 | 0 |
| NEW YORK | 0 | 0 | 0 | 100 |
| NORTH CAROLINA | 0 | 0 | 0 | 100 |
| NORTH DAKOTA | 0 | 0 | 0 | 100 |
| OHIO | 0 | 0 | 0 | 100 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 0 | 0 | 0 | 100 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 0 | 0 | 0 | 100 |
| UTAH | 0 | 0 | 0 | 100 |
| VERMONT | 0 | 0 | 0 | 0 |
| VIRGINIA | 0 | 0 | 0 | 100 |
| WASHINGTON | 0 | 0 | 0 | 100 |
| WEST VIRGINIA | 0 | 0 | 0 | 100 |
| WISCONSIN | | | | |
| WYOMING | 0 | 0 | 0 | 0 |

N is not known.
No.entry indicates lack of response.

# TABLE B-14

## STATE LAB WORK LOAD RADIOLOGICAL

| | NUMBER OF SAMPLES PRESENTLY ANALYZED | POTENTIAL NUMBER OF SAMPLES ANALYZED |
|---|---|---|
| ALABAMA | | |
| ALASKA | 0 | N |
| ARIZONA | N | 0 |
| ARKANSAS | | |
| CALIFORNIA | 1,000 | 1,000 |
| COLORADO | 670 | 670 |
| CONNECTICUT | N | N |
| DELAWARE | | |
| DISTRICT OF COLUMBIA | | |
| FLORIDA | N | N |
| GEORGIA | 0 | 0 |
| HAWAII | 0 | 0 |
| IDAHO | N | N |
| ILLINOIS | | |
| INDIANA | 0 | 10 |
| IOWA | 700-900 | N |
| KANSAS | 0 | 0 |
| KENTUCKY | 4 | 8 |
| LOUISIANA | | |
| MAINE | N | N |
| MARYLAND | | |
| MASSACHUSETTS | N | N |
| MICHIGAN | 120 | 120 |
| MINNESOTA | | |
| MISSISSIPPI | | |
| MISSOURI | | |
| MONTANA | N | N |
| NEBRASKA | 0 | 0 |
| NEVADA | | |
| NEW HAMPSHIRE | | |
| NEW JERSEY | N | N |
| NEW MEXICO | 0 | 0 |
| NEW YORK | N | N |
| NORTH CAROLINA | 900 | 900 |
| NORTH DAKOTA | | |
| OHIO | 1,690 | 2,500 |
| OKLAHOMA | | |
| OREGON | | |
| PENNSYLVANIA | N | N |
| RHODE ISLAND | 54 | N |
| SOUTH CAROLINA | 800 | N |
| SOUTH DAKOTA | N | N |
| TENNESSEE | | |
| TEXAS | 200 | 250 |
| UTAH | 128 | 7,900 |
| VERMONT | 0 | 0 |
| VIRGINIA | 30 | N |
| WASHINGTON | 0 | 0 |
| WEST VIRGINIA | N | N |
| WISCONSIN | | |
| WYOMING | 0 | 0 |

N is not known.

No entry indicates lack of response.

## TABLE B-15

## PERCENT OF RESIDUAL CHLORINE ANALYSES DONE BY FOUR AGENCIES BY STATE

| | IN-HOUSE | PRIVATE COMMERCIAL | MUNICIPAL | STATE |
|---|---|---|---|---|
| ALABAMA | | | | |
| ALASKA | 30 | 10 | 50 | 10 |
| ARIZONA | 0 | 0 | 0 | 100 |
| ARKANSAS | | | | |
| CALIFORNIA | N | N | N | N |
| COLORADO | 99 | 0 | 0 | 1 |
| CONNECTICUT | N | N | N | N |
| DELAWARE | | | | |
| DISTRICT OF COLUMBIA | | | | |
| FLORIDA | N | N | N | N |
| GEORGIA | 0 | 0 | 0 | 0 |
| HAWAII | 60 | 0 | 0 | 40 |
| IDAHO | 0 | 0 | 100 | 0 |
| ILLINOIS | | | | |
| INDIANA | 100 | 0 | 0 | 0 |
| IOWA | 80 | 0 | 80 | 20 |
| KANSAS | 95 | 0 | 0 | 5 |
| KENTUCKY | 75 | 0 | 25 | 0 |
| LOUISIANA | | | | |
| MAINE | 100 | 0 | 0 | 0 |
| MARYLAND | | | | |
| MASSACHUSETTS | N | N | N | N |
| MICHIGAN | 100 | 0 | 0 | 0 |
| MINNESOTA | | | | |
| MISSISSIPPI | | | | |
| MISSOURI | | | | |
| MONTANA | N | N | N | N |
| NEBRASKA | 95 | 0 | 0 | 5 |
| NEVADA | | | | |
| NEW HAMPSHIRE | | | | |
| NEW JERSEY | N | N | N | N |
| NEW MEXICO | 0 | 0 | 95 | 5 |
| NEW YORK | 100 | 0 | 0 | 0 |
| NORTH CAROLINA | N | N | N | N |
| NORTH DAKOTA | 100 | 0 | 0 | 0 |
| OHIO | 100 | 0 | 0 | 0 |
| OKLAHOMA | | | | |
| OREGON | | | | |
| PENNSYLVANIA | N | N | N | N |
| RHODE ISLAND | N | N | N | N |
| SOUTH CAROLINA | 65 | 0 | 0 | 35 |
| SOUTH DAKOTA | N | N | N | N |
| TENNESSEE | | | | |
| TEXAS | 100 | 0 | 0 | 0 |
| UTAH | 0 | 0 | 100 | 0 |
| VERMONT | 0 | 25 | 75 | 0 |
| VIRGINIA | 100 | 0 | 0 | 0 |
| WASHINGTON | 95 | 0 | 5 | 0 |
| WEST VIRGINIA | 0 | 0 | 90 | 10 |
| WISCONSIN | | | | |
| WYOMING | 0 | 0 | 90 | 10 |

N is not known.

No entry indicates lack of response.

## TABLE B-16

## NUMBER OF SYSTEMS BY TYPE & SOURCE

| | SURFACE WATER COMMUNITIES | GROUND WATER COMMUNITIES | SURFACE WATER TRANSIENTS | GROUND WATER TRANSIENTS | FINISHED |
|---|---|---|---|---|---|
| ALABAMA | | | | | |
| ALASKA | N | N | N | N | N |
| ARIZONA | 12 | 1,900 | N | N | N |
| ARKANSAS | | | | | |
| CALIFORNIA | 300 | 800 | N | N | N |
| COLORADO | 179 | 345 | N | 95% | 100 |
| CONNECTICUT | N | N | N | N | N |
| DELAWARE | | | | | |
| DISTRICT OF COLUMBIA | | | | | |
| FLORIDA | N | N | N | N | N |
| GEORGIA | 130 | 2,500 | 0 | 100 | 200 |
| HAWAII | 50+ | 75+ | N | N | 0 |
| IDAHO | 125 | 820 | 175 | 878 | 12 |
| ILLINOIS | | | | | |
| INDIANA | 50 | 393 | N | 10,000 | 20 |
| IOWA | 54 | 768 | N | N | N |
| KANSAS | 2 | 450 | 0 | N | 8 |
| KENTUCKY | N | N | N | N | 119 |
| LOUISIANA | | | | | |
| MAINE | 66 | 104 | N | N | N |
| MARYLAND | | | | | |
| MASSACHUSETTS | N | N | N | N | N |
| MICHIGAN | 96 | 1,878 | 10 | 16,000 | 242 |
| MINNESOTA | | | | | |
| MISSISSIPPI | | | | | |
| MISSOURI | | | | | |
| MONTANA | N | N | N | N | N |
| NEBRASKA | 2 | 450 | 0 | N | 8 |
| NEVADA | | | | | |
| NEW HAMPSHIRE | | | | | |
| NEW JERSEY | 46 | N | N | N | N |
| NEW MEXICO | 17 | 353 | N | N | N |
| NEW YORK | 400 | 735 | N | N | 400 |
| NORTH CAROLINA | 169 | 2,470 | N | N | 68 |
| NORTH DAKOTA | 33 | 224 | N | N | N |
| OHIO | 167 | 1,485 | 100 | 19,000 | 113 |
| OKLAHOMA | | | | | |
| OREGON | | | | | |
| PENNSYLVANIA | 500 | 3,875 | 0 | 11,800 | N |
| RHODE ISLAND | 10 | 31 | N | N | N |
| SOUTH CAROLINA | 70 | 1,000 | 25 | 1,353 | 200 |
| SOUTH DAKOTA | 20 | 350 | 5 | 600 | 1 |
| TENNESSEE | | | | | |
| TEXAS | 400 | 6,000 | 150 | 10,000 | 500 |
| UTAH | 25 | 600 | 5 | 500 | 40 |
| VERMONT | 133 | 238 | 100 | 3,000 | N |
| VIRGINIA | 137 | 1,166 | 0 | 9,400 | 50 |
| WASHINGTON | 100 | 1,400 | 50 | 2,000 | 100 |
| WEST VIRGINIA | 170 | 360 | N | 200 | 120 |
| WISCONSIN | | | | | |
| WYOMING | 46 | 372 | 16 | 410 | 6 |

N is not known.
No entry indicates lack of response.

## APPENDIX C

## DESCRIPTION OF PUBLIC NON-COMMUNITY SYSTEMS BY USE CATEGORY

This appendix describes a breakdown of public non-community supply systems based on use category. Very few states have compiled this information, and of those that have, it appears that the data are still grossly incomplete. New York State was able to provide their breakdown of known non-community public water supplies, which is found in Table C-1. This accounts for only 9,634, or approximately 27 percent, of the NSF estimated 36,000 systems for that state.

Noting that the numbers in the first three categories (food service establishments, schools, and state institutions) should be reasonably close to the actual numbers distributed, an extrapolation was made to estimate the percentage of systems which belong to the final four categories (industrial, commercial, condominiums, and miscellaneous). This was accomplished by weighting each unknown category according to its number of known supplies, and distributing the appropriate percentages among the 82.28 percent of the unknown category systems. The results are given in Table C-2 along with a nationwide breakdown based on these percentages.

It was difficult to determine the limits and the range of applicability of these categories due to the lack of data, and therefore these results should be used with caution.

However, the figure trends appear to be compatible with assumptions made for similar estimations by the EPA Water Supply Division in a study of drinking water systems on and along interstate highways (Table C-3).

A further breakdown of the miscellaneous category into Federally administered components is presented in Table C-4. These data are presented in publications by the administering agency responsible for the sub-category given.

There are a large number of travellers who use small non-community water systems, although it is again difficult to specify quantitative data on populations serviced by the systems from each category. The problem is further complicated by the fact that there are quite significant seasonal variations in the water demand from non-community supply systems, especially from recreational areas. The following assumptions can be made with some confidence:

1. Drinking water supplies serving food service establishments, schools, state institutions, apartments, and industry cater to at least 25 persons per day for 75 percent of the year;

2. Drinking water supplies serving recreational areas and facilities cater to at least 25 persons per day for 35 percent of the year in the northern United States and 90 percent of the year in the southern United States;

3. Service to commercial business establishments is difficult to generalize due to size and type of business, and must be investigated on a categorical and regional basis.

Average annual system utilization for Federally administered facilities are presented in Table C-5. No other concrete results could be generated.

Accurate cost analysis cannot yet be made of treatment methods for these facilities, since there is a significant lack of data in many categories. It has become quite evident that little, if any, national effort has been placed in this area. Little useful information has been obtained from the few studies that have been completed by the joint ventures of the National Sanitation Foundation and the Conference of State Sanitary Engineers, by the EPA. Future emphasis in this area will have to proceed at the state-by-state inventory. In this report, all non-community systems are assumed to serve an average of 25 people a day for all 12 months of the year.

APR 0 3 REC'D

# TABLE C-1

STATE OF NEW YORK
DEPARTMENT OF HEALTH
DIVISION OF SANITARY ENGINEERING
ESP - TOWER BUILDING
FOURTH FLOOR - ROOM 438
ALBANY, N.Y. 12237

Robert P. Whalen, M.D.
COMMISSIONER

MEREDITH H. THOMPSON, D. ENG.
ASSISTANT COMMISSIONER

BUREAU OF RESIDENTIAL & RECREATION SANITATION

IRVING GROSSMAN, P.E.
DIRECTOR

April 1, 1975

Mr. Berry Gahron
185 Alewisebrook Parkway
Cambridge, Massachusetts 02138

Dear Mr. Gahron:

Doctor Thompson has asked me to supply you with information regarding non-municipal public water supplies in New York State.

The table below shows the number of known supplies by region and category at this time.

| | REGIONS | | | | | | |
|---|---|---|---|---|---|---|---|
| | Albany | Buffalo | Rochester | Syracuse | White Plains | TOTAL | |
| Food Service Establishments | 1,145 | 202 | 422 | 955 | 2,994 | 5,718 | 6,380 |
| Schools | 146 | 14 | 22 | 103 | 230 | 515 | |
| State Institutions | 35 | 3 | 40 | 12 | 57 | 147 | |
| Industrial | 33 | 18 | 89 | 41 | 71 | 252 | 3,254 |
| Commercial | 459 | 20 | 300 | 175 | 167 | 1,121 | |
| Condominiums & Apt. Complexes | 62 | 2 | 2 | 5 | 104 | 175 | |
| Miscellaneous | 24 | 129 | 336 | 472 | 745 | 1,706 | |
| Regional Totals | 1,904 | 388 | ~~750~~ 1211 | ~~1,766~~ 1,763 | 4,368 | | |

Statewide Total = ~~9,176~~ 9,634

The numbers in the first three categories should be reasonably close to the actual numbers of these establishments. This cannot be said of the remaining categories. At this time, no estimate can be given of the total numbers of these establishments. The reported numbers are simply the known supplies.

The commercial category includes commercial business establishments such as service stations, stores, shopping centers and grocers.

Examples of some establishments included in the miscellaneous category are resorts, bathing beaches, trailer parks, camps, springs and town and county buildings.

If you have any questions on these figures or require additional information, please feel free to contact this office.

Very truly yours,

Dennis J. Corrigan

Dennis J. Corrigan
Sanitary Engineer
Residential Sanitation Section

TABLE C-2

CATEGORY PERCENTAGE BREAKDOWN BASED ON NEW YORK STATE DATA AVAILABLE

| | CATEGORY | PERCENTAGE SYSTEMS IN CATEGORY (%) | ESTIMATED NUMBER OF SYSTEMS IN UNITED STATES[2] |
|---|---|---|---|
| 1. | Food Service Establishments | 15.88 | 36,582 |
| 2. | Schools | 1.43 | 3,294 |
| 3. | State Institution | 0.41 | 945 |
| 4. | Industrial[1] | 6.37 | 14,674 |
| 5. | Commercial[3] | 28.31 | 65,217 |
| 6. | Condominiums and Apartments | 4.46 | 10,274 |
| 7. | Miscellaneous[4] | 43.14 | 99,381 |
| | TOTAL | 100.00 | 230,367 |

Assumptions:

1. Categories 4 through 7 based on weighted data (see text).

2. Nationwide breakdown based on NSF estimates and New York data.

3. Commercial category includes commercial business establishments such as service stations, stores, shopping centers and grocers.

4. Micellaneous category includes resorts, beaches, parks, camps, springs, and town and country buildings.

# TABLE C-3

## DRINKING WATER SYSTEMS ALONG INTERSTATE HIGHWAYS

### SUMMARY OF THE CATEGORIES OF WATER SYSTEMS SURVEYED

| System Category | | Virginia | Oregon | Kansas | Total | |
|---|---|---|---|---|---|---|
| | | | | | Number | Percent |
| Safety Rest Area | | 9 | 10 | 10 | 29 | 24 |
| Commercial Service Facilities | Service Station | 20 | 18 | 22 | 60 | 50 |
| | Restaurant | 3 | 6 | 8 | 17 | 14 |
| | Motel | 7 | 6 | 0 | 13 | 12 |
| Total | | 39 | 40 | 40 | 119 | 100 |

Source: U.S. Environmental Protection Agency, Drinking Water Sources On and Along the National System of Interstate and Defense Highways, A Pilot Study, Water Supply Division, August 1971, p. 13.

TABLE C-4

## FEDERALLY ADMINISTERED NON-COMMUNITY WATER SUPPLY SYSTEMS[a]

| SUBCATEGORY | NUMBER OF SYSTEMS | POPULATION SERVED ANNUALLY |
|---|---|---|
| 1. U.S. Forest Service | 10,000 | $71 \times 10^6$ |
| 2. Interstate Highways | 9,115 | $1,250 \times 10^6$ |
| 3. U.S. Bureau of Reclamation | 260 | $55 \times 10^6$ |
| 4. U.S. National Park Service | 425 | $216 \times 10^6$ |

[a] Federally administered supplies account for about 20 percent of the miscellaneous category in Table C-2.

### TABLE C-5

### AVERAGE ANNUAL FEDERAL WATER SUPPLY UTILIZATION (NOT SEASONALLY ADJUSTED)

| | SUBCATEGORY | USE (PEOPLE/SYSTEM/DAY) |
|---|---|---|
| 1. | U.S. Forest Service | 19 |
| 2. | Interstate Highways | 137 |
| 3. | U.S. Bureau of Reclamation | 580 |
| 4. | U.S. National Park Service | 1,390 |

## APPENDIX D

## WATER SUPPLY SYSTEM QUESTIONNAIRES

A questionnaire (Figure D-1) was sent to the 207 water supply systems which were found to exceed one or more maximum contaminant levels, as determined in the 1969 CWSS study. Of these 207 systems, replies were obtained from 114 systems (Table D-1), of the remaining 93 systems, 17 no longer operate, 17 others have consolidated, and 59 could not be contacted.

This initial questionnaire dealt mainly with treatment and analysis costs and techniques employed. The responses concerning analysis are summarized in Table D-2. This shows that over 63 percent of the inorganic and 70 percent of the organic and bacteriological analyses are done by some form of governmental laboratory. Another important finding of the study is that seven out of the eight water supply systems contacted which distribute purchased water do not analyse the water in their distribution system.

The responses to the treatment questions indicate that only 15 systems have changed their treatment techniques since discovering their violation on 1969. These changes are listed in Table D-3.

A second telephone questionnaire (Figure D-2) was utilized to supplement the financial and cost data information of the 114 respondents listed above.

### TABLE D-1

### SUMMARY OF RESPONDENTS TO WATER SUPPLY SYSTEM QUESTIONNAIRE

| | |
|---|---|
| Number sent out | 207 |
| Systems which no longer operate | 17 |
| Systems which could not be located | 43 |
| Systems which have consolidated and therefore no response | 17 |
| Systems which operate seasonally only and no response | 16 |
| Municipal (and other governmental agency) systems responding | 78 |
| Private systems responding | 36 |
| Total | 207 |

## TABLE D-2

## SUMMARY OF RESPONSES FROM WATER SUPPLY SYSTEMS QUESTIONNAIRE

| 1. | Costs of Analysis | Range ($) |
|---|---|---|
| | 1) Inorganic[a,b] | 0 - 144.00 |
| | 2) Organic[a,b] | 0 - 60.00 |
| | 3) Bacteriological[a] | 0 - 7.50 |

2. Analysis Done By:

| | STATE | COUNTY | MUNICIPAL LAB | PRIVATE LAB | OTHER |
|---|---|---|---|---|---|
| 1) Inorganic | 27 | 5 | 8 | 23 | 3 |
| 2) Organic | 23 | 5 | 6 | 15 | 3 |
| 3) Bacteriological | 27 | 7 | 11 | 18 | 4 |

---

[a] $0 costs are for those systems where state or other governmental agency incurs the cost of analysis.

[b] The costs for inorganic and organic analyses are for partial analyses only.

## TABLE D-3

## CHANGES IN TREATMENT TECHNIQUES TO CORRECT FOR VIOLATIONS OF 1969 PHS STANDARDS

| CONTAMINANT | NEW TREATMENT |
|---|---|
| $NO_3$ | Blending |
| Pb | pH Control |
| Fluoride | New well |
| Turbidity | Coagulation, filtration, sedimentation |
| Turbidity | New source |
| $NO_3$ | Blending |
| Se | Blending |
| $NO_3$ | Blending |
| Fluoride | Inject less fluoride into system |
| Pb | Change pipes |
| Coliform | Chlorinator |
| $NO_3$ | Blending |
| Pb | Flush system |
| Turbidity | Coagulation, filtration, sedimentation |
| Coliform | Chlorinator |

FIGURE D-1

## QUESTIONNAIRE TO WATER SUPPLY SYSTEMS

1. NAME OF SUPPLY: ______________________________

2. LOCATION: ______________________________

3. PERSON FILLING OUT QUESTIONNAIRE: ______________________________

4. PHONE # ______________________________

5. POPULATION SERVED: ______________________________

6. CURRENT PRODUCTION (MGD): ______________________________

7. TOTAL VOLUME SUPPLIED IN 1974
   (SPECIFY UNITS): ______________________________

8. TREATMENT METHODS USED: (PLEASE CHECK)

| | | | TREATMENT PROCESS ADDED SINCE 1970 | |
|---|---|---|---|---|
| | YES | NO | YES | NO |
| a. Disinfection | | | | |
| b. Coagulation | | | | |
| c. Sand Filter | | | | |
| d. Fluoridation | | | | |
| e. Taste and Odor Control | | | | |
| f. Lime Softening | | | | |
| g. Ion Exchange | | | | |
| h. Settling | | | | |
| i. Iron Removal | | | | |
| j. Other (Please List) | | | | |
| k. Do you use zeolite for: | | | | |
| 1) Iron Removal | | | | |
| 2) Softening | | | | |

### 9. ANALYSIS INFORMATION

| | State Lab | Municipal Lab | Private Lab | Other |
|---|---|---|---|---|
| a. Inorganic Analysis Done By: | ___ | ___ | ___ | ___ |
| b. Date of Last Inorganic Analysis: | ________________________ | | | |
| c. Cost of Analysis: | ________________________ | | | |
| d. Organic & Pesticide Done By: | ___ | ___ | ___ | ___ |
| e. Date of Last Organic Analysis: | ________________________ | | | |
| f. Cost of Analysis: | ________________________ | | | |
| g. Bacteriological Analysis Done By: | ___ | ___ | ___ | ___ |
| h. Date of Last Bacteriological Analysis: | ________________________ | | | |
| i. Cost of Analysis: | ________________________ | | | |

### 10. QUALITY OF INFLUENT WATER

a. Do you Treat for a Particular Contaminant in the Influent Water? (e.g., Lead, Coliform, CCE, etc.) ____________________

b. How Frequently do you Monitor the Influent Water?

| Daily | Monthly | Yearly | Other |
|---|---|---|---|
| ___ | ___ | ___ | ___ |

### 11. QUALITY OF EFFLUENT WATER

a. In 1969 you exceeded the 1962 PHS Standard for ________________ (i) and ______________ (ii). Please list any corrective actions taken to rectify this violation.

(i) ____________

Capital Cost ______________
Annual Operating Cost (OVHD & Maint.) ______________
Total Annual Cost ______________

(ii) ____________

Capital Cost ____________
Annual Operating Cost (OVHD & Maint.) ____________
Total Annual Cost ____________

b. Are you now in Compliance with These Standards? ________

c. What are your Current Concentrations of These Parameters?

____________ ____________
____________ ____________
____________ ____________
____________ ____________

d. Have you have any New Problems with Other Pollutants? ______
(If so, Please Specify) ____________________

12. CURRENT OVERHEAD AND MAINTENANCE COSTS FOR TREATMENT

| | | $/Unit of Time |
|---|---|---|
| a. | Labor | ____________ |
| b. | Supplies | ____________ |
| c. | Chemicals (Please List at end of Questionnaire) | ____________ |
| d. | Electric Power | ____________ |
| e. | Total | ____________ |

13. WHAT ARE THE ANNUAL FIXED COSTS OF YOUR PLANT? $____________

Year ____________

14. HOW MANY EMPLOYEES IN WATER SYSTEM:

| Full Time | Part Time |
|---|---|
| ________ | ________ |

15. WHAT IS THE RATE STRUCTURE FOR WATER SALES?

| AMOUNT | UNIT (Gal., Cu.Ft.) |
|---|---|
| ________ | ________ |

16. METHOD OF CHARGING? Meters_____ Flat Rate_____ Other_____

17. PROFITS $__________ Year __________

18. DEPRECIATION $__________ Year __________

19. ESTIMATES ON UPGRADING CURRENT TREATMENT FACILITIES:

(If you are planning an expansion or change in treatment techniques, please specify contaminant you will treat for.)

a. Capital Costs

| | |
|---|---|
| Land | $__________ |
| Equipment | $__________ |
| Site Development | $__________ |
| Total | $__________ |

b. O&M Costs

| | |
|---|---|
| Labor | $__________ |
| Supplies | $__________ |
| Chemicals | $__________ |
| Electric Power | $__________ |
| Other | $__________ |
| Total | $__________ |

20. CAPITAL FINANCING

| | Amount Realized | Interest or Dividend Rate(%) |
|---|---|---|
| a. General Obligation Bonds | $__________ | __________ |
| b. Revenue Bonds | $__________ | __________ |
| c. Debenture Bonds | $__________ | __________ |
| d. Mortgage Bonds | $__________ | __________ |
| e. Bank Loans | $__________ | __________ |

| | | | |
|---|---|---|---|
| f. | Preferred Stock | $__________ | __________ |
| g. | Common Stock | $__________ | __________ |
| h. | Other | $__________ | __________ |
| | | __________ | __________ |
| i. | Total | $__________ | __________ |

21. The Proposed Interim Standards allow for total substitution of chlorine residual monitoring in place of coliform density measurements for systems serving 4,900 or fewer persons provided the system maintains a residual of no less than 0.3 mg/l free chlorine. If the system serves more than 4,900 people, chlorine residual monitoring may be substituted for not more than 75% of the required coliform measurements if a residual of no less than 0.2 mg/l free chlorine is maintained in the public water distribution system. This substitution would reduce the overall monitoring costs of the Proposed Standards considerably. Do you feel that your system would use this chlorine residual option? YES____ NO____

22. COMMENTS:

FIGURE D-2

CODE: ____________

1. NAME OF WATER SUPPLY: ______________________________

2. PHONE #: __________

3. PERSON SUPPLYING INFO.: ______________________________

4. OWNERSHIP ☐ MUNICIPAL ☐ PRIVATE ☐ OTHER GOV'T

RATE STRUCTURE:

5. ____ dollars for ____ units RESIDENTIAL or flat rate of $ ______

6. ____ dollars for ____ units COMMERCIAL or flat rate of $ ______

7. ____ dollars for ____ units INDUSTRIAL or flat rate of $ ______

CURRENT REVENUES RAISED FROM: Answer either in \$ or % of total.

8. ________ RESIDENTIAL

9. ________ COMMERCIAL

10. ________ INDUSTRIAL

11. ________ TAX REVENUES Either as SURPLUS (+) or SUBSIDY (-) or

________ TOTAL REVENUE If can't get #'s 8, 9, 10, or 11

# OF CUSTOMERS:

12. RESIDENTIAL ________

13. COMMERCIAL ________

14. INDUSTRIAL ________

15. CURRENT ANNUAL O&M COST INCLUDING: A OPERATION & MAINTENANCE + B INTEREST ON DEBT IF ANY, C AMOUNT OF MONEY PUT ASIDE TO RETIRE DEBT, IF ANY: ______________________________

16. WHAT IS TOTAL PRODUCTION? ______________________________

17. WHAT IS TOTAL POPULATION SERVED? ______________________________

18. A WHO ARE THE 2 OR 3 LARGEST CUSTOMERS AND HOW MUCH WATER DO THEY USE? ______________________________

______________________________

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B IF INDUSTRIAL CONCERN WHAT DO THEY PRODUCE?______________

______________________________________________

C WHAT IS TOTAL BILL OF CONCERN?______________________________

19. WHAT IS A TYPICAL RESIDENTIAL BILL?___________________________

20. IS WATER SYSTEM AN INDEPENDENT AGENCY ____ OR TIED IN WITH OTHER AGENCIES (SEWER, ETC.)?______________________________

21. HOW DOES THE SYSTEM FINANCE EXPANSION? ____ BONDS?____LOANS? ____SHARES?

22. WHAT IS THE CURRENT INDEBTEDNESS OF THE SYSTEM?______________

# APPENDIX E

## CONTAMINANT REMOVAL BY CONVENTIONAL WATER TREATMENT PROCESSES

### E.1 Removal of Turbidity

There are a number of conventional water treatments which are employed, either singly or in combination, for the removal of turbidity from water intended for human consumption. Turbidity is imparted to water by suspended solid particles whose sizes are so small as to constitute a nonsettleable colloidal suspension.

High turbidity levels render water unacceptable for human consumption both for aesthetic and health reasons. The origins of turbidity particulates are partly mineral (including possibly toxic heavy metals), partly organic, and partly microbiological (including possible disease causing microorganisms). Moreover, high turbidity interferes with disinfection and other treatment practices.

Although filtration by itself sometimes suffices to reduce turbidity to acceptable levels, chemical treatments are commonly practiced to induce coagulation and flocculation. The resulting coalescence into larger particles allows partial settling and increases filtration efficiency.

The chemicals most commonly used for coagulation and flocculation are aluminum sulfate [$Al_2(SO_4)_3$] or alum, and iron (III) sulfate [$Fe_2(SO_4)_3$]or ferric alum. Both alum and ferric alum are water soluble, but at medium to high values of pH, they react with water to form solid hydroxides in the form of gelatinous precipitates which incorporate the turbidity particles into easily filtered or settleable masses.

In principle, these "flocs" of aluminum and ferric hydroxides have a potential to absorb dissolved solids including toxic heavy metals and other inorganics which fall under the primary standards. Control of $Ba^{++}$ by precipitation as the insoluble sulfate salt is also possible from considerations of chemical equilibrium. Studies have been performed on the following species to determine removal efficiencies through coagulation, flocculation, and filtration: organic mercury

($CH_3HgCl$)[1,2] , inorganic mercury ($HgCl_2$)[1,2], Barium ($Ba^{++}$)[2], inorganic selenium (IV)[2], inorganic selenium (VI)[2], inorganic arsenic (III)[2,3], inorganic arsenic (V)[2,3], and total chromium.[4] The results are shown in Table E-1.

In the studies by Logsdon and Symons, the removal efficiencies of mercury tended to parallel initial levels of turbidity[1]. The failure of sulfate ion to remove barium was attributed to supersaturation[2]; the importance of oxidation states was noted for selenium and arsenic[2]. It was observed that selenium is primarily a ground water problem and that the reduced state [Se(IV)] should therefore predominate[2]. (Fortunately Se(IV) is the easier of the two to remove.) Laboratory[2,3]and field studies both showed that chlorination improves the removal efficiency for arsenic, presumably thorugh oxidation of As(III) to As(V).

## E.2 Chlorination

Chlorination is very widely practiced as a means of disinfecting public water supplies, and its use in the United States has reduced the once epidemic incidence of water-borne disease to almost negligible proportions.

---

[1] G.S. Logsdon and J.M. Symons, "Mercury Removal by Conventional Water Treatment Techniques," J. Am. Water Works Assn., 65, 554 (1958).

[2] G.S. Logsdon and J.M. Symons, "Removal of Heavy Metals by Conventional Treatment," in J.E. Sabadel, editor, "Traces of Heavy Metals in Water Removal Processes and Monitoring," United States Environmental Protection Agency Report #902/9-74-001, Region II, 1973, pp. 225-56.

[3] Y.S. Shen, "Study of Arsenic Removal from Drinking Water," J. Am. Water Works Assn., 65, 543 (1973).

[4] G.M. Zemansky, "Removal of Trace Metals During Conventional Water Treatment," J. Am. Water Works Assn., 66, 606 (1974).

TABLE E-1

## REMOVAL OF HEAVY METALS BY COAGULATION, FLOCCULATION AND FILTRATION

| SPECIES | APPROXIMATE PERCENT REMOVAL | | TYPE OF STUDY | REFERENCE[d] |
|---|---|---|---|---|
| | ALUM | FERRIC ALUM | | |
| Organic Mercury | <30 | <30 | Jar Test | 1,2 |
| Inorganic Mercury | <30 | 30-60 | Jar Test | 1,2 |
| Barium | <30 | <30 | Jar Test | 2 |
| Inorganic Selenium (IV) | <30 | 60-80 | Jar Test | 2 |
| Inorganic Selenium (VI) | <30 | <30 | Jar Test | 2 |
| Inorganic Arsenic (III) | <30 | 50-80 | Jar Test | 2 |
| Inorganic Arsenic (V) | 60-90 | 90-100 | Jar Test | 2 |
| Total Arsenic[a] | 50-80 | | Jar Test | 3 |
| Total Arsenic[b] | 100 | | Jar Test,<br>Field Survey | 3 |
| Total Chromium[c] | 0-60 | | Field Survey | 4 |

[a] Ferric chloride coagulation.

[b] Chlorination followed by ferric chloride coagulation.

[c] Coagulants not specified.

[d] See footnotes, preceding page.

When $Cl_2$ dissolves in water at a neutral pH, it disproportionates:

$$Cl_2 + H_2O \rightarrow H^+ + Cl^- + HClO \qquad (1)$$

forming hydrochloric acid and hypochlorous acid (HClO). All the disinfecting and oxidizing power of "aqueous chlorine" resides in the hypochlorous acid. The pH is of course lowered.

Several of the inorganic chemicals listed in the primary standards are affected by chlorination. Trivalent arsenic (As(III)) is oxidized to the pentavalent state (As(V)). Tetravalent selenium (Se(IV)) does not oxidize rapidly in the presence of HClO, but standard oxidation potentials predict that it should be converted to Se(VI). Nitrite ($NO_2^-$) is oxidized to nitrate ($NO_3^-$). Free cyanide ($CN^-$) is destroyed, but some cyanide complexes are resistant to chlorination. Chlorination can potentially destroy some organometallic compounds. (The reaction of HClO with methyl mercury should therefore be investigated).

Aqueous chlorine reacts readily with ammonia. The resulting chloramines retain much of the disinfecting power of chlorine and represent much longer-lasting chlorine residuals (combined chlorine residual), but are much weaker oxidizing agents. Thus, when ammonia is present in the water (either naturally or by deliberate addition), under these conditions, the reactions as cited in the previous paragraph are not as likely to take place.

Aqueous chlorine also reacts with organics to produce chlorinated organics, such as those found in the New Orleans water supply last year and implicated in the high incidence of bladder cancer in that city. One possible benefit of this reaction, however, is that the chlorinated organics are probably more completely adsorbed on activated carbon than are their precursors.

## E.3 Activated Carbon Filtration

Filtration through activated carbon is a well known, effective treatment for water with high levels of odor and color. This is due to carbon's extraordinary capacity to adsorb organic molecules onto its surface. It is likely that activated carbon filtration would constitute adequate treatment for water with excessive levels of total organics (as measured by carbon chloroform extraction) and of pesticides.

Logsdon and Symons have investigated the removal of several trace metal species with activated carbon.[1] Effective removals of both organic and inorganic mercury were observed with removal efficiencies of up to 100 percent using granular activated carbon in columns. They found that activated carbon was ineffective against barium, selenium and arsenic. Smith,[2] however, has reported that when carbon is prepared with a high content of oxygenated surface groupings, it functions as an ion exchange medium and is therefore a good adsorber of ionic species. Carbon's other removal mechanisms include true adsorption, precipitation, oxidation or reduction to insoluble forms, and mechanical filtration. Smith's literature survey disclosed effective removals of Cr, Pb, Ni, Cd, Zn, Fe, Mn, Ca, Al, Bi, Cu, Ge, as well as the aforementioned work on Hg. Suitable carbons can be prepared by heating carbon in the presence of oxygen or by slurrying it with nitric acid.

It should be noted that activated carbon has a 100 percent removal efficiency for chlorine.

## E.4 Lime Softening

In lime softening, calcium hydroxide ($Ca(OH)_2$) is used as a base to convert the natural bicarbonate ($HCO_3^-$) content of water to carbonate ($CO_3^=$). The pH of course rises. As a result, the insoluble compounds $CaCO_3$, $MgCO_3$ and (in the case of excess lime softening) $Mg(OH)_2$ form and fall out of solution as precipitates.

Lime softening has many variations, depending both on the composition of the feed water and on the desired quality of the finished water. In addition to lime, a particular lime softening process may also use $CO_2$, $Na_2CO_3$, or NaOH. Ordinary lime softening raises pH to the range of 8-10; in excess lime softening the pH goes over 10 but is later reduced - for example, by aeration with $CO_2$ (a weak acid).

---

[1] Logsdon and Symons, "Mercury Removal by Conventional Water Treatment Techniques," 1958.

[2] S.B. Smith, "Trace Metals Removal by Activated Carbon," in J.E. Sabade, pp. 55-70.

Lime softening can cause some heavy trace metals to precipitate as hydroxides or carbonates; it can also convert species such as $HAsO_2$, $H_2AsO_4^-$, and $HAsO_4^=$, which are soluble in the presence of $Ca^{++}$ to $AsO_2^-$ and $AsO_4^{\equiv}$, whose calcium salts precipitate.

Hem and Durum[1] have studied the equilibrium solubility of lead as a function of carbonate and pH, and concluded that a pH of 8 is sufficient to reduce the dissolved lead content to a level which is less than 10 percent of the maximum value permitted by the primary standards. Lime softened water should therefore satisfy the lead standard, and moreover should be incapable of dissolving lead pipes and lead joints in water distribution systems.

Logsdon and Symons[2] have studied the effectiveness of lime softening on mercury (both organic and inorganic), barium, arsenic (III), arsenic (V), selenium (IV) and selenium (VI). Their results are summarized in Table E-2. The arsenic results parallel those for ferric alum coagulation. They found that chlorination of As(III) followed by lime softening achieved removal efficiencies characteristic of As(V).

TABLE E-2

REMOVAL OF TRACE HEAVY METALS WITH LIME

| SPECIES | APPROXIMATE PERCENT REMOVAL<br>pH 8.5-9.5 | pH 10.5-11.5 |
|---|---|---|
| Organic Mercury | 0 | 0 |
| Inorganic Mercury | 20-40 | 60-80 |
| Barium | 60-90 | 80-95 |
| Inorganic Selenium (IV) | ~20 | 20-50 |
| Inorganic Selenium (VI) | <10 | <10 |
| Inorganic Arsenic (III) | 10-20 | 60-80 |
| Inorganic Arsenic (V) | 30-50 | 90-100 |

---

[1] J.D. Hem and W.H. Durum, "Solubility and Occurrence of Leak in Surface Water," J. Am. Water Works Assn., 65, 562 (1973).

[2] Logsdon and Symons, "Mercury Removal by Conventional Water Treatment Techniques," 1958.

# APPENDIX F

## CHEMISTRY OF REMOVAL OF CONTAMINANTS FROM DRINKING WATER SYSTEMS

This section considers the removal of chemical contamination on a species-by-species basis. The discussion in this section is based solely on theoretical chemical considerations. A subsequent section discusses this on a process-by-process basis.

### F.1 Arsenic

Aqueous arsenic occurs as oxyanions in the III and V oxidation states.[1] The degree of protonation depends on pH. Arsenite ($AsO_2^-$) and arsenate ($AsO_4^{\equiv}$) are rather basic while arsenic acid ($H_3AsO_4$) is a strong acid. Arsenite is more toxic than arsenate. Arsenate (V state) is easily removed from water by coagulation, either with alum or ferric sulfate or by lime softening, especially at excess levels (pH 10.6-11). Arsenite (III state) is less well removed,[2] but chlorination rapidly converts it to arsenate.

### F.2 Barium

Aqueous barium occurs as the ion: $Ba^{++}$. The sulfate and carbonate are its only important insoluble salts, however, treatment with sulfate[1] (as in alum or ferric sulfate coagulation) was found to be ineffective for its removal. The carbonate, however, is well-behaved and can apparently be precipitated out during lime softening or pH control at pH 1011. Cation exchange is also effective in removal of $Ba^{++}$.

---

[1] General chemical properties obtained from standard texts such as F.A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, Interscience, 1962.

[2] G.S. Logsdon and J.M. Symons, "Removal of Heavy Metals by Conventional Treatment," in J.E. Sabadel, editor, "Traces of Heavy Metals in Water Removal Processes and Monitoring," United States Environmental Protection Agency Report #902/0-74-001, Region II, 1973, pp. 225-56.

CWSS listed one barium violation at 1.55 mg/l; the system practices chlorination, coagulation, aeration, settlement, and rapid sand filtration.

### F.3 Cadmium

Aqueous cadmium occurs in the III oxidation state. There are not hard data on the removal of cadmium by standard treatment processes; however, the chemistry of cadmium parallels that of lead, and since lead can be controlled by pH control, this technique may also be effective against cadmium. However, on a molar basis, cadmium must be controlled to a residual that is three times lower than lead ($0.9\times10^{-8}$M. vs. $2.4\times10^{-8}$), but the solubility products are higher for both the hydroxide ($K_{sp}$ $(Cd(OH)_2)$ = $2.0\times10^{-14}$, $K_{sp}$ $(Pb(OH)_2)$ = $4.0\times10^{-15}$)[2] and the carbonate ($K_{sp}(CdCO_3)$ = $5.2\times10^{-12}$, $K_{sp}(PbCO_3)$ = $1.0\times10^{-13}$), so it is not clear that pH control would constitute an adequate treatment. Cation exchange would be effective in the absence of another suitable treatment.

The CWSS data base shows nine systems in violation of the cadmium standard (0.010 mg/l). Table F-1 shows the observed levels and treatment practices in the nine systems.

---

[1] Environmental Health Service, Bureau of Water Hygiene, USPHS, "Community Water Supply Study--Analysis of National Survey Findings," Department of HEW, July 1970, and data base thereto.

[2] Equilibrium constants were obtained from tables in, A.F. Clifford, Inorganic Chemistry of Qualitative Analysis, (Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1961).

## TABLE F-1

## CADMIUM VIOLATIONS

| LEVEL mg/l | TREATMENTS IN USE |
|---|---|
| .011 mg/l | Chlorination |
| .012 | Chlorination |
| 3.94 | None |
| .022 | Chlorination |
| .011 | Chlorination, Rapid Sand, Filtration, Fluoridation |
| .022 | Chlorination |
| .023 | None |
| .108 | None |
| .012 | Chlorination |

### F.4 Chromium

Aqueous cadmium occurs in the III state as $Cr^{3+}$ and in the VI state as chromate ion ($CrO_4^{2-}$). Chromate is regarded as the more toxic of the two species. The only datum on chromium removal by conventional treatment shows an average of about 30 percent removal of total chromium ($Cr^{3+}$ and $CrO_4^{2-}$ ratio not measured) by lime and alum coagulation, settlement, and filtration.[1] $Cr^{3+}$ should be totally removed through formulation of $Cr(OH)_3$ ($K_{sp} = 10^{-31}$) and $CrO_4^{2-}$ should be unaffected. Cation exchange would similarly remove $Cr^{3+}$ but not $CrO_4^{2-}$. Unfortunately, it is the latter species that needs control. One possibility would be to add $Na_2S$ or $(NH_4)_2S$. The sulfide would act to reduce $CrO^{2-}$ to $Cr^{3+}$ and then precipitate $Cr(OH)_3$. The excess sulfide could be subsequently destroyed by chlorination.

The CWSS data base shows nine systems in violation of the chromium standard (p.05 mg/l). Details may be found in Table F-2.

---

[1] G.M. Zemansky, "Removal of Trace Metals During Conventional Water Treatment," *J. Am. Water Works Assn*, *66*, 606 (1974).

## TABLE F-2

## CHROMIUM VIOLATIONS

| LEVEL mg/l | TREATMENTS IN USE |
|---|---|
| 0.051 | Chlorination, Còagulation, Rapid Sand Filtration |
| 0.060 | None |
| 0.079 | Aeration, Rapid Sand Filtration |
| 0.074 | Chlorination |
| 0.073 | None |
| 0.200 | Chlorination |
| 0.079 | Chlorination |
| 0.62 | Chlorination |
| 0.072 | Chlorination, Rapid Sand Filtration |

### F.5 Cyanide

Aqueous cyanide occurs as the free ion, $CN^-$, and complexed with heavy metals (for example, $Fe(CN)_6^{4-}$. The free ion is acutely toxic, the complexes generally less so. However, the complexes can act as precursors of free cyanide; for example ($Fe(CN)_6^{4-}$ releases $CN^-$ under the influence of sunlight. Cyanide can be destroyed by chlorination or ozonolysis. Ozonolysis will also destroy the cyanide content of $Fe(CN_6^{4-}$ and $Fe(CN)_6^{3-}$.

### F.6 Lead

Aqueous lead occurs as the ion $Pb^{+3}$. Lead contamination of drinking water can occur from automobile exhaust and smelter emissions, industrial discharges of lead contaminated water, and lead leached from landbearing rock. Probably the most important source is the lead piping in some older water distribution systems. Appreciable corrosion of such pipes can occur under some conditions of water alkalinity and pH. According to equilibrium studies,[1] the solubility of lead in water is under 10ug/l for high pH ($\geq 8.0$) and alkalinity (100 mg/l as $CaCO_3$). Thus, pH control would appear to be an effective method both for removal of lead at the treatment plant and for prevention of the corrosion of lead pipes. Cation exchange would remove lead at the treatment plant, but would probably enhance lead pipe corrosion through removal of $Ca^{++}$ and prevention of a protective coating of $CaCO_3$ inside lead pipes. Coagulation has been found to be ineffective.

---

[1] J.D. Hem and W.H. Durum, "Solubility and Occurrence of Lead in Surface Water," J. Am. Water Works Assn., 65, 562 (1973).

Of all the heavy metals studies in the CWSS, lead was responsible for the most violations, i.e. 40. These are detailed in Table F-3.

## F.7 Mercury

The aqueous chemistry of mercury is quite complex. In addition to the free ions, $Hg_2^{++}$ and $Hg^{++}$, there are complex ions, such as $HgOH^+$, soluble neutral species such as $HgCl_2$ and $Hg(OH)_2$, and organic mercurials such as $CH_3Hg^+$ (methyl mercury). The latter is probably the most toxic of the aqueous species.

The complexity of the water chemistry of mercury would make a priori prescriptions of treatment practices both difficult and unreliable. Fortunately, there exists a detailed experimental study of the problem.[1,2] In this study, samples of raw Ohio River water, raw Glendale River water, Ohio well water, and Cincinnati, Ohio tap water were spiked either with $HgCl_2$ or $CH_3HgCl$ and treated in jar-test procedures. Alum coagulation resulted in up to 60 percent removal of HgCl and up to 30 percent removal of $CH_3HgCl$, the higher percentages corresponding to greater initial turbidity.

---

[1] G.S. Logsdon and J.M. Symons, "Removal of Heavy Metals by Conventional Treatment," pp. 225-56.

[2] G.S. Logsdon and J.M. Symons, "Mercury Removal by Conventional Water Treatment Techniques," J. Am. Water Works Assn., 65, 554 (1973).

## TABLE F-3

## LEAD VIOLATIONS

| Level | Treatments in Use | Sample From Distribution System |
|---|---|---|
| 0.075 mg/l | None | Yes |
| 0.081 | Chlorination | Yes |
| 0.229 | None | Yes |
| 0.078 | None | Yes |
| 0.088 | Chlorination | Yes |
| 0.118 | Chlorination | Yes |
| 0.114 | None | Yes |
| 0.054 | None | Yes |
| 0.179 | None | Yes |
| 0.386 | None | Yes |
| 0.147 | None | No |
| 0.069 | Chlorination | Yes |
| 0.644 | None | Yes |
| 0.324 | Chlorination | Yes |
| 0.101 | Chlorination | Yes |
| 0.074 | None | No |
| 0.497 | Chlorination | No |
| 0.060 | Chlorination | No |
| 0.128 | None | Yes |
| 0.138 | Chlorination, Aeration, Rapid Sand Filtration | Yes |
| 0.070 | Chlorination, Rapid Sand Filtration | Yes |
| 0.078 | Chlorination, Aeration, Coagulation | Yes |
| 0.108 | Chlorination | No |
| 0.072 | None | Yes |
| 0.320 | None | Yes |
| 0.063 | Chlorination, Coagulation, Rapid Sand Filtration, Settlement, Taste and Odor Control | Yes |
| 0.098 | Chlorination, Coagulation Aeration, Rapid Sand Filtration Settlement, Taste and Odor Control | Yes |
| 0.052 | Chlorination | Yes |
| 0.152 | Chlorination, Coagulation, Aeration, Rapid Sand Filtration, Settlement | No |
| 0.273 | Chlorination | No |
| 0.130 | Chlorination | Yes |
| 0.052 | Chlorination | Yes |
| 0.057 | None | Yes |
| 0.096 | None | Yes |
| 0.074 | Chlorination | Yes |
| 0.073 | None | No |
| 0.118 | None | Yes |
| 0.076 | Chlorination | Yes |
| 0.055 | None | Yes |

# TABLE F-4

## NITRATE VIOLATIONS

| Level (as $NO_3^-$) | Treatments in Use | Ground Supply |
|---|---|---|
| 54.9 | None | Yes |
| 97.5 | Chlorination | Yes |
| 49.4 | None | Yes |
| 49.2 | Chlorination | Yes |
| 48.7 | Chlorination | Yes |
| 79.5 | Chlorination | Yes |
| 45.7 | Chlorination | Yes |
| 50.5 | Chlorination | Yes |
| 48.4 | Chlorination | Yes |
| 75.4 | None | Yes |
| 47.4 | None | Yes |
| 46.2 | None | Yes |
| 46.0 | None | Yes |
| 77.0 | Chlorination, Rapid Sand Filtration | Yes |
| 46.1 | Chlorination | Partially |
| 60.6 | Chlorination | Yes |
| 55.3 | Chlorination | Yes |
| 49.5 | None | Yes |
| 51.1 | Chlorination | Yes |
| 61.1 | Chlorination | Yes |
| 97.4 | Chlorination, Rapid Sand Filtration | Yes |
| 61.7 | Chlorination | Yes |
| 45.3 | Chlorination | Yes |
| 46.0 | Chlorination | Yes |
| 0.011mg/l | Chlorination | Yes |
| 0.014 | Chlorination | No |
| 0.018 | None | Yes |
| 0.018 | Chlorination | Yes |
| 0.065 | Chlorination | Yes |
| 0.016 | Chlorination | Yes |
| 0.061 | Chlorination | Yes |
| 0.011 | Chlorination | Yes |
| 0.012 | None | Yes |
| 0.017 | None | Yes |
| 0.013 | None | Yes |

Ferric sulfate coagulation turned out to be somewhat more effective, especially for $HGCl_2$ in low turbidity water. Lime softening (pH 10.7 - 11.1) was effective in removing about 70 percent of the $HgCl_2$, independent of initial mercury concentrations ranging from 1 to 25 μg/l. However, no $CH_3HgCl$ was removed. Activated carbon, in both powdered and granular forms, was effective in removing both $HgCl_2$ and $CH_3HgCl$. A dosage of powdered carbon of 1 mg/l for each 0.1 μg/l of mercury was sufficient to reduce mercury to a final concentration of 2 μg/l. In all three processes the removal mechanism seemed to be adsorption.

There are no data on mercury content in the CWSS. However, in an EPA survey[1] of 273 water supplies, only three supplies exceeded the EPA standard of 0.002 mg/l, and 261 supplies had concentration under 0.001 mg/l.

## F.8 Nitrate

Nitrate occurs in water as the free ion, $NO_3^-$. It has little tendency to form complexes with metal ions, and all its salts are appreciably soluble. Therefore, conventional water treatment practices would seem to be ineffective in its removal. Chlorination has an effect on its concentration inasmuch as it will oxidize any $NO_2^-$ (nitrite) that is present to nitrate. Since nitrate is an anion, catonic exchange will not remove it from solution.

The CWSS data base shows 24 violations of the 1962 standard (45 mg/l). This is equivalent to 10.1 mg/l $NO_3^-$ as N, and since the new proposed standard is 10 mg/l $NO_3^-$ as N, these represent essentially the same standard.

## F.9 Selenium

Aqueous selenium occurs as selenite ($SeO_3^{=}$, oxidation state IV) and selenate ($SeO_4^{=}$, oxidation state IV). Their redox reactions have slow rates; the likelihood of converting one species to the other during water treatment is small. In jar test studies[1] it was found that selenite was best removed (60-80%) by ferric sulfate coagulation as pH 7. Lime softening (pH=9-1) achieved 20-40 percent removal. Alum coagulation and activated carbon were ineffective. None of these methods were effective in removing selenate.

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[1] R. J. Hammerstrom, et al., "Mercury in Drinking Water Supplies," *J. Am. Water Works Assn.*, *64*, 60 (1972).

The authors observed that selenium is largely a ground water problem, and since ground waters are usually of a reducing nature, any selenium found would be in the reduced (or selenite) form, and would therefore be subject to ferric sulfate coagulation.

The CWSS lists 11 selenium violations (selenium >0.01 mg/l). These are detailed in Table F-5.

## F.10 Silver

Aqueous silver occurs as the free ion $Ag^+$ and as a number of complexes, the most important of which is $Ag(NH_3)_2^+$. Assuming chemical equilibrium, a concentration of chloride of 10 mg/l is sufficient to hold the free silver ion content below the maximum permitted level of 0.15 mg/l. Chlorination, therefore, would be of some effect in removal of silver from drinking water, since chlorine gas generates chloride ions when it is dissolved in water.

The CWSS lists no violations of the silver standard.

## F.11 Fluoride

Fluoride ion, $F^-$, occurs as a natural constituent of drinking water in many parts of the country and is often added to water supplies where it does not occur naturally. This has been done as a public health measure, as water containing approximately 1 mg/l of $F^-$ has been found to suppress tooth decay in children. Substantially higher concentrations of $F^-$ (>3 mg/l) are disfiguring, however, giving a brown or black "mottled" appearance, and are thus not permitted under EPA water quality standards.

Removal of excess $F^-$ is a difficult problem. The two standard water treatments which have some potential for removal are activated alumina and bone char; even these

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[1] G.S. Logsdon and J.M. Symons, "Removal of Heavy Metals by Conventional Treatment," pp. 225-56.

# TABLE F-5

## SELENIUM VIOLATIONS

| Level (mg/l) | Treatments in Use | Groundwaters |
|---|---|---|
| 0.011 | Chlorination | Yes |
| 0.014 | Chlorination | No |
| 0.018 | None | Yes |
| 0.018 | Chlorination | Yes |
| 0.065 | Chlorination | Yes |
| 0.016 | Chlorination | Yes |
| 0.061 | Chlorination | Yes |
| 0.011 | Chlorination | Yes |
| 0.012 | None | Yes |
| 0.017 | None | Yes |
| 0.013 | None | Yes |

treatments do not always work. The CWSS reports[1] that three water systems attempted to remove fluoride but that two of those attempts were unsuccessful.

The CWSS lists 35 systems in violation of the 1963 PHS standards for fluoride. The maximum permitted levels range from 0.8 to 1.7 mg/l, depending on annual average high temperature. Details are shown in Table F-6.

## F.12 Carbon Chloroform Extractibles

Carbon Chloroform Extractibles (CCE) are organic chemicals with little or no polarity and limited water solubility. Some examples are benzene, carbon tetrachloride, polychlorinated biphenyls (PCB's), phenolics, and many pesticides. Many problems of color and odor in drinking water are related to CCE content. Treatment with activated carbon seems to be an excellent method for removal of CCE (activated carbon is used as an agent for the collection of CCE samples). Treatment by chlorination can have mixed results. It is well known that phenol when treated with limited amounts of chlorine reacts to form chlorinated phenols with intense disagreeable odors. Excess chlorine, however, will decompose these chlorinated phenols, the products probably including carbon tetrachloride and other chlorinated hydrocarbons. The result is a "New Orleans drinking water problem", in which chlorination has generated potential carcinogens from more or less innocuous organic precursors.

Although these arguments seem to suggest that chlorination would be avoided where raw waters contain appreciable amounts of organics, it is possible that excess chlorination would promote the subsequent removal of organics by activated carbon adsorption. Some of the methyl chloroform found in the New Orleans water supply may have resulted from the action of chlorine on ethyl alcohol, a substance not removed by carbon adsorption; methyl chloroform, however, is removed by carbon adsorption. It would therefore be worthwhile to investigate the effectiveness of the following sequence of processes for treating raw waters with organic contamination: 1) excess chlorination, 2) carbon filtration, 3) chlorine disinfection. (Step 3 is necessary because carbon adsorption tends to remove chlorine.)

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[1] Community Water Supply Study, "Analysis of National Survey Findings," pp. 225-56.

## TABLE F-6

## FLUORIDE VIOLATIONS

| Level (mg/l) | Treatments in Use | Level (mg/l | Treatments in Use |
|---|---|---|---|
| 1.98 | Chlorination, Fluoridation | 1.52 | Chlorination, Coagulation, Rapid Sand Filtration |
| 3.60 | Chlorination | | |
| 2.60 | Chlorination, Fluoridation | 1.80 | Chlorination |
| 3.10 | None | 1.48 | None |
| 3.00 | None | 3.60 | None |
| 2.65 | None | 3.40 | None |
| 3.70 | Chlorination | 4.00 | Chlorination |
| 3.00 | None | 2.20 | Fluoridation |
| 2.00 | None | 1.70 | None |
| 3.70 | Chlorination | 1.81 | Chlorination |
| 1.71 | Rapid Sand Filtration, Chlorination, Aeration | 2.43 | None |
| | | 3.04 | None |
| 4.40 | Chlorination | 2.82 | Chlorination |
| 1.90 | Chlorination | 1.90 | None |
| 3.00 | Chlorination | 2.26 | Chlorination |
| 1.65 | Chlorination | 2.37 | None |
| 1.90 | Chlorination, Rapid Sand Filtration | 2.00 | None |
| | | 8.00 | Chlorination |
| 1.60 | Chlorination | 1.85 | None |
| | | 1.72 | None |

The CWSS lists 22 CCE violators of the proposed EPA standard of 0.7 mg/l. Although CCE is primarily a surface water problem as illustrated by these data, some ground supplies may also be contaminated. The details are in Table F-7.

## TABLE F-7

## CCE VIOLATIONS

| Level (mg/l) | Treatments in Use | Groundwater |
|---|---|---|
| 0.854 | None | No |
| 2.485 | None | No |
| 0.727 | None | No |
| 1.846 | None | No |
| 2.62 | None | No |
| 0.804 | Chlorination | No |
| 0.830 | Rapid Sand Filtration, Chlorination, Aeration | No |
| 1.120 | None | No |
| 3.278 | Chlorination | No |
| 0.728 | Chlorination | No |
| 1.339 | Chlorination | No |
| 0.990 | Chlorination | No |
| 0.782 | None | No |
| 1.972 | None | No |
| 0.894 | None | No |
| 0.843 | Fluoridation | No |
| 1.02 | None | No |
| 1.010 | Fluoridation | No |
| 2.86 | Chlorination | No |
| 0.992 | None | No |
| 1.210 | Chlorination | No |

# APPENDIX G

## DATA BASE AND COST ESTIMATES OF WATER TREATMENT

This appendix presents the development of cost functions for water treatment processes used in this study. The origins of the data base utilized are also included. This description should provide the necessary background to the cost estimates for water treatment to meet the Proposed Drinking Water Regulations.

The description is divided into two main sections. Section G.1 illustrates the cost functions and estimates for larger water supply systems (systems that supply more than 1,000 $m^3$/day [264,000 gpd]). Section G.2 describes the corresponding costs for small systems. The need for such a distinction stems from the fact that cost functions for large supply systems are not very valid for systems of smaller capacity. Consequently, different sets of functions were devised for the processes being considered, which include the following: (1) clarification (consisting of direct filtration), (2) chlorination, (3) activated carbon, (4) ion exchange, (5) lime-soda softening, and (6) activated alumina.

Prior to the presentation of these cost functions, the associated assumptions are stated below:

1. To estimate the quantity of water production, the average daily production shown in Table 4-2 was used for each population category;
2. Electricity costs 3 cents per kilowatt-hour;
3. Land costs $202 per hectare;
4. Capital costs generally included expenses for equipment purchase, installation, construction, design engineering study, land, site development, and construction overhead. Operating and maintenance costs (O&M) include labor, supplies, materials, chemicals, electric utility, and general maintenance;
5. The interest rate is 7 percent.

## G.1 Large System Costs

The cost functions for large water supply systems were generated primarily from the results of the report by D. Volkert & Associates.[1] These functions, which have been compared favorably with another report,[2] are summarized in Table G-1. The first column lists the treatment processes. The second column lists the cost estimates, and the third column indicates the appropriate comments for that process. It should be noted that the cost estimates are for individual processes; cascading them in series may lead to lower costs. Moreover, these functions are only valid for plants with capacities between 1,000 $m^3$/day (264,000 gpd) and 300,000 $m^3$/day (78 mgd). For the cost functions, the following keywords are used:

C = Construction cost

OM = Annual O&M costs, excluding labor

A = Area of land in hectares

SD = Site developemnt cost

L = Annual labor cost

OML = Annual O&M costs, including labor

Q = Plant capacity in $m^3$/day

Unless specified, these cost estimates are in terms of 1973 dollars. They have to be adjusted to 1975 dollars using the discount factor.

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[1] David Volkert & Associates, Monograph of the Effectiveness and Cost of Water Treatment Processes for the Removal of Specific Contaminants, Vol. I, Technical Manual (Bethesda, Maryland: David Volkert & Associates, 1972).

[2] I.C. Watson, Study of the Feasibility of Desalting Municipal Water Supplies in Montana. Manual for Calculation of Conventional Water Treatment Costs, Supplement to Final Report (Arlington, Virginia: Resources Studies Group, 1972).

TABLE G-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| COAGULATION & SEDIMENTATION | $C = 45000(Q/1000)^{0.796}$<br>$SD = 40000(Q/1000)^{0.66}$<br>$L = 6400(Q/1000)$<br>$OM = 2700(Q/1000)$<br>$A = 0.074(Q/1000)$ | 1. Flash water<br>2. Usually followed by filtration |
| FILTRATION | $C = 64000(Q/1000)^{0.676}$<br>$SD = 11000(Q/1000)^{0.761}$<br>$L = 11000(Q/1000)^{0.948}$<br>$OM = 14149\ (Q/1000)^{0.948}$<br>$A = 0.026(Q/1000)$ | 1. Rapid sand filter for a rate of 10 $m^3/m^2$/day |
| CHLORINATION | Equipment cost = $3700(Q/1000)^{0.533}$<br>Enclosure structure cost = $800(Q/1000)$<br>Cost of chlorine per year = (\$0.55/kg) x 365 Q x (dosage in mg/1) x 4.01 x $10^{-3}/0.7$ | 1. Use solution feed<br>2. Assume 4 mg/1 dosage |

TABLE G-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| ACTIVATED CARBON | C for absorption $= 23000(Q/1000)^{0.849}$<br>C for carbon regeneration $= 12000(Q/1000)^{0.656}$<br>$OML = 21000(Q/1000)^{0.146}$<br>OM supplies $= 9000(Q/1000)^{0.169}$<br>Annual fuel cost $= 300(Q/1000)^{0.606}$<br>Granular carbon replacement cost per year $= 300(Q/1000)$ | 1. Granular carbon used.<br>2. Three month replacement. |
| ACTIVATED ALUMINA | $C = 22000(Q/1000)^{0.631}$<br>$OML = 3200(Q/1000)^{0.785}$<br>Chemical cost for each mg/l of fluoride removed per year $= 2300(Q/1000)$ | |

TABLE G-1

COST ESTIMATES OF TREATMENT PROCESSES FOR LARGE SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| ION EXCHANGE | $C = 0.22 \times 10^6 (Q/100)^{0.703}$<br>$SD = 52000(Q/1000)^{0.666}$<br>$OML = 16000(Q/1000)^{0.47}$<br>OM Supplies = 0.01C<br>Resin replacement cost = 0.03C<br>Annual power cost<br>$= 0.03 \times 360 \times 365$<br>$\times (Q/1000)^{0.87}$<br>$A = 0.03(Q/1000)$<br>Annual chemical cost<br>$= 5 \times 10^{-5} \times 365Q$<br>x (ppm reduction) | 1. Assume 1000 ppm reduction in TDS |
| pH Control | Cost of lime = 2¢/kg<br>Cost of soda ash = 8.5¢/kg<br>Amount of lime used per year in kg<br>$= (1.42 \times CO_2 + 0.623$<br>$(T + M)) \times (Q/1000)$<br>Amount of soda ash in kg/year<br>$+ 1.081(M + CNH) \times (Q/1000)$<br>Equipment cost<br>$= 3700(Q/1000)^{0.533}$<br>Enclosure cost = 800(Q/1000) | 1. $CO_2$ is concentration of $CO_2$ in mg/1 as $CaCO_3$. (Assumed 84 mg/1)<br>Similarly, T is total alkalinity, (328 mg/1)<br>M the required magnesium reduction, (120 mg/1)<br>and CNH calcium non-carbonate hardness. (10 mg/1) |

## G.2 Small System Costs

In this study, a small system is considered to be one producing less than 264,000 gallons (1,000 $m^3$) per day. Assuming a water requirement of 100 to 150 gallons per capita per day, the flow rate range of interest is from about 2,500 gallons per day (≈ 10 $m^3$/day) to about 300,000 gpd (≈1,100 $m^3$/day).

Cost information for small systems was obtained through (1) personal conversation with several water treatment equipment manufacturers and suppliers, and (2) a study of conventional water supply costs conducted by Control Systems Research, Inc. for the Office of Saline Water, U.S. Department of the Interior.[1]

The approach used in requesting cost information from vendors was as follows. First, each manufacturer or supplier was queried as to the exact nature of his business. This allowed obtained cost data to be qualified in terms of actual type of equipment and services supplied for a stated price. The various business functions of the vendors contacted included suppliers of $40 cartridge filter products for home use, manufacturers of treatment unit "packages" for commercial/ industrial use, suppliers of complete clarification systems for small municipal systems and/or industrial use, and suppliers of treatment systems designed to handle site-specific problems. Confidence in survey results was gained by considering responses only in terms of the vendor categories from which the responses came.

Secondly, each vendor was asked to provide general cost information (capital, installation, O&M) for equipment customarily used in water treatment applications within the flow rate range of interest. It was acknowledged that facilities and equipment provided in a given application is determined from several factors including; (1) raw water quality, (2) desired product water quality, (3) flow rate, (4) existing facilities, (5) system and equipment flexibility, (6) operation and maintenance needs of equipment, and other site-specific characteristics.

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[1] I.C. Watson, Resources Studies Group, CSR, Inc., Manual for Calculation of Conventional Water Treatment Costs (Washington, D.C.: Office of Saline Water, U.S. Department of the Interior, March 1972).

Since site-specific factors are not easily quantified on a general basis, vendors were asked for a general indication of costs. Responses were therefore based on either general equipment catalogue costs or actual vendor experience in providing facilities for small systems.

Information received from vendors was supplemented with cost data contained in the aforementioned CSR[1] study, which was based largely on equipment cost information provided by vendors. The CSR report was prepared with an emphasis on developing cost curves for systems used in municipal application and was designed to provide a means for estimating the costs of conventional treatment systems on the basis of individual unit operations. Cost functions derived from CSR data reflect 1972 prices and are thus multiplied by the appropriate factor in order to present results in 1975 dollars. A 7 percent interest rate was assumed.

Cost estimating functions for small systems are presented below in tabular form with appropriate comments regarding the equipment and services represented by each function. A list of vendors contacted is then presented. The following nomenclature is used:

C = Capital equipment cost

I = Equipment installation costs

O&M = Equipment operation and maintenance costs, annual

GPD = Gallons per day

Q = Plant capacity in cubic meters per day

GPM = Gallons per minute

SE = Site and enclosure costs

IMC = Initial media costs

It should be pointed out here that the cost curves for small and large systems will not produce a continuous function. The main reason for this is that each set of curves was developed independently and perhaps under differing assumptions.

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[1] Control Systems Research Inc. is now known as KAPPA Systems Inc., Arlington, Virginia.

The cost differences that occur at the small and large system breakpoint do not materially affect the overall cost estimates. In any event, it was not within the scope of this project to develop a single continuous function for all system sizes covered by the Act.

However, because of the tremendous range in system size, from 25 persons to over 1,000,000, there are several reasons why it may be difficult to develop a continuous function for all systems:

1. Small systems can employ package plants;
2. Small systems generally do not require full-time maintenance;
3. Small system treatment package plants may not require housing facilities.

TABLE G-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| ACTIVATED CARBON | C and I = $73.5 \times 10^3 [\mathrm{MGD}]\ 0.845$<br>$= 24.4 \times 10^3 \left(\frac{Q}{10^3}\right)^{0.845}$<br>SE = $2.29 \times 10^3 \left[\frac{Q}{10^3}\right]^{0.571}$<br>O&M = $[1.8 \times 10^3 (\mathrm{MGD})^{0.37}]1.07$<br>$= 11.73 \times 10^3 \left(\frac{Q}{10^3}\right)^{0.37}$ | 1. Costs for use of carbon for taste and odor control with light organic load.<br>2. Carbon replacement cost assumed to be 7% of annual O&M.<br>3. C and I are for rubber lined pressure filter vessels, piping, valves etc., but not pumping equipment.<br>4. O&M includes general maintenance, supplies, power, and carbon replacement. |
| ACTIVATED ALUMINA | C and I = $54 \times 10^3 [\mathrm{MGD}]^{0.62}$<br>$= 19.3 \times 10^3 \left(\frac{Q}{10^3}\right)^{0.62} +$<br>$29{,}401 \left(\frac{Q}{10^3}\right)\ 0.98$<br>O & M = $3.8 \times 10^3 \left(\frac{Q}{10^3}\right)\ 0.79$ | 1. C and I includes all equipment for defluoridation system including tanks piping, valves, pumping, and housing.<br>2. O&M includes chemical costs, annual alumina charge, general repairs, media replacement. |

TABLE G-2

COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| CHLORINATION | $C = (0.386)^{Q}/(10)^{2,283}$<br>$O\&M = 0.751^{Q}/(10)^{0.768}$ | 1. For small systems, solution feed hypochlorinators are the most feasible kind of disinfection equipment.<br>2. O&M includes power and chemical costs and normal care of hypochlorinator unit.<br>3. Assumes 4 ppm Cl. |
| CLARIFICATION (COAGULATION, SEDIMENTATION, FILTRATION) | $C \text{ and } I = 1.5 \times 10^{5} \; \frac{GPD}{10^{3}} \; 0.196$<br>$= 4.47 \times 10^{5}\left(\frac{Q}{10^{3}}\right)^{0.196}$<br>$O\&M = 0.06 \; [C \text{ and } I]$ | 1. C and I cost reflects completely Automatic filtration plant for use in treating surface waters to potability standards. Equipment provided includes chemical feed, coagulation, floculation, sedimentation, filtration, and also building with foundation and sanitary services.<br>2. Costs reflect a municipal small system situation where bids on a clarification system would be received.<br>3. Added pumping, piping, drainage not provided.<br>4. C and I and O&M estimates (Maint. supplies, labor, chemical and power costs) compare favorably with CSR data. |

## TABLE G-2

## COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| FILTRATION | $C = (0.277)^{Q}/(10)^{3.917}$<br>$O \& M = (0.101)^{Q}/(10)^{3.140}$ | 1. Costs are for filtration system used for source of water between 0-100 JTU.<br>2. C and I includes filter media and vessel, pumping equipment, piping, and controls for filter system, and erected housing. O&M includes pump power, chemical costs, maint. labor. |
| ION EXCHANGE | $C \text{ and } I = 2 \times 10^{4} \ \frac{GPD}{10^{3}} \ 0.37$<br>$= 2.546 \times 10^{3} \ \frac{Q}{10^{3}} \ 0.37$<br>$O \& M - 0.07 \ [C \text{ and } I]$ | 1. Costs for unit package designed for industrial applications.<br>2. C and I includes demineralizer units with automatic controls, plastic piping, rinse alarm.<br>3. Pumping equipment, pretreatment equipment, chemical storage tanks not included.<br>4. O & M involves pumping care and power, chemical tanks and chemicals, manual tank filling. |

## TABLE G-2

## COST ESTIMATES OF TREATMENT PROCESSES FOR SMALL SYSTEMS (CONT.)

| TREATMENT PROCESS | COST ESTIMATES | COMMENTS |
|---|---|---|
| pH CONTROL | Cost of lime = 2¢/kg<br>Cost of soda ash = 8.5¢/kg<br>Amount of lime used per year in kg<br>$= (1.42 \times CO_2 + 0.623 (T + M)) \times Q/1000)$<br>Amount of soda ash in kg/year<br>$= 1.081(M + CNH) \times (Q/1000)$<br>$C = (0.386)^{Q}/(10)^{2.283}$ | 1. $CO_2$ is concentration of $CO_2$ in mg/l as $CaCO_3$. Similarly, T is total alkalinity, M the required magnesium reduction, and CNH calcium noncarbonate hardness. |

TABLE G-3

SMALL SYSTEM EQUIPMENT MANUFACTURERS CONTACTED

| MANUFACTURER | LOCATION |
|---|---|
| Baker Filtration Co. | Huntington Beach, CA |
| Baroid Division, N.L. Industries | Houston, TX |
| Culligan Company | Northbrook, IL |
| Ecodyne-Craver Water Division | Lenexa, KY |
| Envirotech, Inc. | Belmont, MA |
| General Filter Company | Ames, IA |
| Hayward Filter Company | Santa Anna, CA |
| Hungerford & Terry, Inc. | Clayton, NJ |
| Lea Manufacturing | Waterbury, CT |
| Neptune Microfloc | Corvallis, OR |
| N.Y. Mixing Equipment Co. | Wakefield, MA |
| North American Carbon, Inc. | Columbus, OH |
| Roberts Filter Manufacturing Co. | Darby, PA |
| Wallace & Turnan, Div. of Pennwalt | Belleville, NJ |
| Wastewater Systems, Inc. | Chicago, IL |
| Water Control Equipment Co. | Houston, TX |
| Westcore Associates | Salt Lake City, UT |

# APPENDIX H

# WASTES PRODUCED FOR EFFLUENT GUIDELINES

## H.1 Wastes Resulting From Water Treatment Operations

The effluent limitations imposed under PL 92-500 which require the most sophisticated treatment of wastes resulting from water treatment serve to indicate present technological capabilities for pollutant "handling." The water treatment technologies to be applied in meeting drinking water regulations would produce two main effluent streams: (1) the finished product water, and (2) the unfinished byproducts of the water purification processes. The resultant water borne wastes to be discussed are sludges from softening, coagulation, sedimentation and filtration operations and effluents from filter system regeneration and backwashing.

Sludge management in water purification is a costly activity that affects overall plant efficiency. As supply water quality becomes subject to more stringent regulations, solids management may assume a determining role when choices between alternative processes must be made. This section presents a brief overview of the sources, characteristics, and methods of treatment and disposal of water treatment wastes.

## H.2 Water Treatment Wastes: Characteristics and Treatment

Raw water constituents which can be removed in water treatment include components causing objectionable odor, taste, and color, ions causing hardness, suspended solids, iron, manganese and colloids. Waste-producing water treatment processes include presedimentation, coagulation, softening, iron and manganese removal, filtration and dissolved solids removal. The process or processes to be used in a given plant are determined by existing raw water constituents and desired product water constituents.

Water treatment plant sludges generally have a low total solids content and wet weight, and a high ratio of suspended solids.[1] Depending upon the sludge producing processes employed, sludge consists of suspended soil particles, colloids, microorganisms, inorganic and organic matter, and precipitates removed in coagulation, softening, and filtration. Sludges vary in terms of treatability, water content, pH, and suspended solids loadings.

## H.3 Coagulation Sludges

Sludges derived from processes using coagulation have a very low solids concentration ( 2%) which presents a problem of water removal. The difficulties of dewatering are related to the gelatinous consistency of the sludge, which may be composed of sand, silt, colloidal organic and inorganic matter, microorganisms, chemicals used for coagulation, and compounds resulting from chemical reactions during coagulation. The volume of sludge produced by a coagulation-flocculation plant is on the range of 1 to 5 percent of the water treated.

Because these sludges are voluminous, thickening of clarification sludges prior to dewatering is a common practice. In addition to reducing sludge volume, thickening (typically with organic polymers) results in a more concentrated slurry for dewatering. An increase in solids concentration by 1 to 3 percent can result in a reduction of sludge volume by two-thirds, depending upon the exact nature of the sludge and the thickening program involved.

The dewatering of coagulation sludges can be carried out in lagoons, vacuum filters, sand drying beds, and filter presses. Alum sludges are difficult to dewater in lagoons, with only a 10 to 15 percent solids content achievable. Further drying is needed because the dewatered sludges are not concentrated enough for direct removal to a landfill. The advantages of low capital costs, maintenance, and energy use are offset by large land requirements, dependence upon climatic conditions for effective operation, and sludge handling expenses.

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[1] J.W. Clark, W. Viessman, Jr., and M.J. Hammer, Water Supply and Pollution Control, 2nd Edition, (Scranton, Pa.: International Textbook Co., 1971.)

Vacuum filtration for dewatering can achieve a filter cake solids content of 20 to 30 percent when precoating is practiced, and a content of 10 to 15 percent when precoating is not practiced. The latter allows filter cloth clogging by metal hydroxide sludge. Vacuum filtration is most often used in dewatering softening sludges.

Dewatering in sand drying beds, with added utilization of air drying and polymeric conditioning agents, can produce sludge cake with about 20 percent solids. The advantages of low labor, maintenance, power needs, capital costs, and long useful life might be offset by high land requirements, dependence upon climatic conditions, and the need for sludge pretreatment and added drying.

Filter presses for mechanically dewatering sludges have not been extensively employed in the past, although this may change in the future since a filter cake solids content of 40 to 60 percent is achievable. The advantages of long useful life, high overload capacity, and low land requirements must be weighed against high capital costs, moderate maintenance and energy needs, and high labor needs. Sludge pre-conditioning may be required in certain cases.

Sludges from coagulation-flocculation processes have been discharged into sanitary sewers in a number of locations, with a reported increase in the removal of solids, BOD, COD and phosphorous in sewage treatment primary sedimentation. In some instances, combined sewage-coagulation sludges are detrimental to activated sludge processes due to reduced sludge densities.[1] The potential for regionalization of sludge treatment and a resultant lowering of dewatering costs (economies of scale) for smaller water-treatment plants is an important consideration for the future.

Coagulation sludge dewatering by centrifugation is not particularly effective, although the use of polyelectrolytes to condition the sludge can improve performance. A maximum cake solids concentration of 15 to 16 percent is achievable under optimum conditions.[1]

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[1] U.S. Environmental Protection Agency, Development Document for Effluent Limitations Guidelines and Standards of Performance - On a Study of the Water-Supply Industry (Draft Final Report): Washington, D.C., March 6, 1975. SORI-EAS-75-103.

## H.4 Chemical Softening Sludges

The principal component of the sludges resulting from chemical softening operations is calcium carbonate, which contributes 80 to 90 percent of the weight of solids in the sludge. Other constituents include silt, organics, and hydrated metal oxides. The solids content of settled softening sludges may range from 2 to 30 percent, and dewatering is generally easier than with coagulation sludges. Gelatinous solids may reduce the treatability of softening sludges, which accumulate in volumes of 3 to 5 percent of the volume of the water treated. Lime sludges can be thickened prior to dewatering to more than 35 percent solids.

Depending upon the type of lagoon used in detwatering, solids concentrations (by weight) of 20 to 50 percent can be achieved due to the higher specific gravities of sludge particles. In general, however, lagooned sludge must be further dewatered, with lagoons serving primarily as a thickening and storage process. Added sludge handling costs must be considered.

Vacuum filtration is best applied in dewatering calcium carbonate sludges. Filter cakes containing as much as 80 percent solids have been obtained, although this percentage decreases as the magnesium hydroxide fraction of the sludge increases. For sludge derived from coagulation-softening processes, cake solids concentrations of over 60 percent have been achieved.

Calcium carbonate sludges are so much more amenable to dewatering than metal hydroxide sludges that sand bed drying has not been widely used. For combined coagulation-softening sludges, sand bed dewatering is more effective as the lime sludge portion increases.

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[1] U.S. Environmental Protection Agency, Development Document for Effluent Limitations Guidelines, March 6, 1975.

Filter press installations for the dewatering of lime sludge do not yet exist, but test studies indicate filter cake solids in the 40 to 50 percent range. This has been achieved without pre-conditioning the sludge to enhance dewatering. Generally, a high sludge magnesium content adversely affects the solids' settling success. For combined coagulation-softening sludges, preliminary experience indicates that filter performance is better as the fraction of softening sludge increases.

Rapid settling characteristics and the large volumes of sludge to be handled have created problems whenever softening sludges have been discharged into sanitary sewer systems. Problems include sewer system sludges, digestor overloads, and sludge collection mechanism damage. Centrifugation for dewatering lime sludges is practiced widely, particularly in plants having a recalconing cycle. For combined coagulation-softening sludges, centrifuge dewatering results in a paste-like cake having a solids content of 45 to 50 percent.

## H.5 Iron and Manganese Removal Sludges

Iron and manganese removal processes include oxidation with or without chemical assistance, coagulation-clarification, aeration with pH adjustment, manganese zeolite filtration, and ion exchange. Filtration, either in rapid or slow sand filters or in pressure or gravity filters, following oxidation and detention for agglomeration of particles is the preferred technique.

Sludges resulting from these processes are highly colored, and of a gelatinous consistency when the ratio of iron and manganese to silt (or other easily filtered constituents) is high. Hence in addition to precipitate sludge there is a problem of sludge retainment on the filter media. Because of their gelatinous nature, iron-manganese sludges can be as difficult to dewater as coagulant sludges. Pre-conditioning by thickening to up to 6 percent solids content prior to dewatering is generally practiced.

The dewatering of metal hydroxide sludges can be accomplished in precoat vacuum filters or in sand drying beds. For the latter process the addition of polymers and concurrent air drying may be needed for production of a disposable filter cake. In both processes, filter cake solids concentrations of 20 to 30 percent can be achieved. Filter press dewatering of these sludges is not practiced in the United States since the usually gelatinous larger particulate components contribute to poor dewatering.

The discharge of metal hydroxide sludges into sanitary sewer systems is a common practice. Despite their differences in composition, coagulant sludges and metal hydroxide sludges produce similar effects when combined with sewage sludge in waste water treatment processes.

## H.6 Filter Backwash Water

Filter backwash water may contain fine particles of clay and silt, metal hydroxides and oxides, activated carbon, water treatment chemicals, filter media particles, and suspended organic materials. Although washwater volumes of up to 5 percent of the treated volume are common, flow equalization is usually practiced since washwater discharges are intermittent.

Filter backwash streams are recycled in many instances, sometimes after combination with supernatants from lagoons. However, the most common method utilized in disposing of these wastes is direct discharge to nearby watercourses. Where filter washwater streams are treated, lagoons and settling basins appear to be the only processes employed.[1]

## H.7 Other Sludges or Residues

Additional waste producing processes used in the water supply industry include zeolite softening and various fluoridation processes. Brines resulting from zeolite softening contain chlorides of magnesium, sodium, and calcium, while fluoridation brines contain fluorides of calcium and sodium.

In the handling of brine wastes, lagoons have been used with mixed success due to high salt concentrations which retard evaporation (and which increase as evaporation proceeds). When evaporation is successful, residual salts must be disposed of. In addition, brine seepage through porous soils can result in the mineral contamination of nearby surface and ground waters.

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[1] American Water Works Research Foundation, Disposal of Wastes From Water Treatment Plants, New York, August 1969.

Due to the chloride ion component of brine wastes, direct disposal to streams, lakes, or other water bodies without significant dilution volumes can result in toxicity problems for aquatic life, livestock, and agricultural crops. Although ionic strength may be increased as a result of brine discharge to sanitary sewer systems, this disposal method generally enhances dilution of brine wastes. Flow equalization equipment is needed in this case to prevent "sludge" loading of wastewater plants. Principal concerns are the maintenance of the sewage plant's biological balance and minimization of corrosion effects on plant facilities.

### H.8 Additional Waste Handling Processes

Other treatment and/or disposal processes which have been proposed for use in the treatment of water plant wastes include freezing, spray irrigation, land reclamation, sludge plowing, heat drying, and specialty recovery. Abandoned mine as well as ocean dumping has been used as an ultimate disposal option in some cases.[1]

### H.9 Recycling/Recovery Processes

The discussion above reveals that contemporary technology for the control and treatment of water plant wastes consists mainly of solids separation followed by disposal. These are carried out in a variety of ways -- lagooning, thickening, dewatering, disposal to sewers, drying in beds, land disposal, ocean disposal, deep well injection, and dilution (brine wastes).

Recovery or recycle processes for several water plant waste components are currently available. The recovery of lime, alum, brines, and some magnesium compounds and the recycling of filter backwash water are examples of processes which can reduce waste production as well as chemical costs.

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[1] U.S. Environmental Protection Agency, Development Document for Effluent Limitations Guidelines, March 6, 1975

## H.10 Filter Backwash Recycling

Backwash recycle facilities usually include equalization equipment to keep recycle feed rates below 5 percent of the plant raw water flow. When clarification is practiced only the supernatant is recycled but sludge removal facilities are needed. Recycling has only a minimal effect on the net production of waste solids from a water treatment plant, and instances of both reduced and increased coagulant requirements have been reported.[1] Odor and taste problems are a concern when filter backwash is recycled.

## H.11 Chemical Recovery

Alum recovery processes involve sludge thickening, sulfuric acid addition for recovery of aluminum at low pH, separation of dissolved aluminium sulfate, aluminium recycling to raw water, dewatered sludge neutralization by lime addition, and landfill disposal of neutralized sludge. Alum recovery reduces waste solids and increases the filterability of the residual sludge.

The principal problems involved are the dissolution of heavy metals and color-causing materials at low pH (2.0). Color building in recovered alum has been reported in pilot plant studies conducted in the United States. Incineration of thickened and dewatered sludge (prior to acidification) to destroy organics has been practiced where recovered alum is used for color removal.

The recovery of lime in softening plants allows a great reduction of the waste solids generated in softening processes and also results in some cost recovery from the sale of excess lime. Also, the carbon dioxide released in calcination is available for use in finished water stabilization. The primary contaminant of interest in lime recovery processes is magnesium hydroxide, which, if not dissolved by carbonation prior to calcination, is converted to magnesium oxide and can build up as an impurity in the recovered lime.

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[1] U.S. Environmental Protection Agency, Development Document for Effluent Limitations Guidelines, March 6, 1975.

Following carbonation, thickening is provided to separate the clear magnesium bicarbonate solution and to concentrate the calcium carbonate. Following dewatering in either vacuum filters or centrifuges, the sludge cake is washed for further removal of magnesium carbonate. Processes for lime recovery are: (1) rotary kiln, (2) multiple hearth furnace, and (3) fluidized bed calcination.

Backwash brines from ion exchange processes can be recovered by conventional lime-soda ash softening, which precipitates the dissolved magnesium and calcium. The resultant insoluble sludge can then be filtered and recycled for reuse.

# APPENDIX I

## UPGRADING PRESENTLY OPERATING WATER TREATMENT PLANTS

The upgrading of existing public supply water treatment plants to meet the Proposed Interim Primary Drinking Water Regulations would have a significant impact on the economy of the supply water industry. The largest portion of the immediate costs would arise due to the purchase of land and equipment, and due to costs associated with retrofit con-construction. The problem is one of great magnitude: estimates presently indicate that at least 65 percent of existing community public water supply systems would require chlorination, that nearly all of the estimated 230,000 non-community supplies would require chlorination, and that about 5 percent of the community systems would require additonal treatment for heavy metals and turbidity, primarily by coagulation and sedimentation.

There are a number of specific problems which would result from retrofitting existing plants to meet the proposed regulations:

1. Retrofitting would require a sudden demand on raw construction materials used for necessary treatment equipment and facilities;
2. Retrofitting would require purchase of additional right-of-way land to facilitate new plant expansion;
3. Retrofitting requires extensive qualified engineering design services. The modification and/or addition of treatment processes to existing plants would encompass problems related to flow characteristics, changes in chemical parameters, additional power requirements, equipment compatibility, efficient utilization of floor area, and other such problems;
4. Addition of new equipment would require additional plant operational and maintenance skills and additional process monitoring personnel. It could also require more extensive laboratory capabilities. For example, ion exchange columns must be monitored frequently to

determine percent capacity utilization, and the resins must either be regenerated or replaced on a regular basis;

6. Preliminary studies by the engineer to accurately determine those components of the supply water that violate the standards would need to be long-range;

7. Retrofitting equipment could require temporary interruption of normal operations of the plant, and consequent interruption of water supply;

8. Upgrading of plants would have to be approached on a case-by-case basis to meaningful.

It is doubtful that any state public works department would be adequately staffed to handle the engineering and construction responsibilities that would be required to meet the proposed regulations. Vermont alone has indicated that it would need to increase its present staff six to ten times in order to adequately implement the regulations. For this reason, it is anticipated that professional engineering consulting firms would be retained to do preliminary studies, design, and to oversee construction of retrofitting plants, particularly for the larger community water supply systems. Although the pre-engineering costs are included in the section of this report dealing with unit process costs, a closer look at this phase of the implementation scheme is presented here to clarify the components of the total cost of upgrading each project.

The engineer retained for each specific plant suspected of violation of the regulations would have to supply both basic and special services. Generally, basic services would include preliminary field investigations and data collection to determine which contaminants could be considered violations of the regulations. In addition, report preparation, treatment process and equipment designs, drawings, and specifications would all be required. Further, basic services would include securing bids, awarding contracts, inspecting construction, testing and approving equipment for acceptance, and making appraisals. Special services provided by the engineer might include studies, tests and process determinations performed to establish design criteria. Other special services might be soils investigations, mill, shop and lab inspections of materials and equipment, investigations involving operation and maintenance, and overhead expenses, preparation of applications and supporting documents for projects grants, and preparation of operation and maintenance manuals. It is assumed that alterations and changes in existing structures and facilities would involve more engineering work than the building of a new plant.

Qualification and experience are of critical importance in the selection of a consulting engineer. His decisions affect costs that influence the economic feasibility of the project undertaken. Retaining a competent design firm might require higher compensation initially, but would result in substantially lower overall project costs in the end.

Compensation for the engineering of upgrading water supply treatment facilities would most likely be on a cost-plus-fixed payment basis. This method of payment is usually performed on projects in which the actual costs and scope of the projects cannot be accurately determined. The preliminary studies necessary to determine which contaminants of the effluent water violate regulations require that work begin before the actual problem is known. The engineer is reimbursed for the individual elements of salary, overhead, and direct non-salary expenses, and in addition receives a fixed amount for contingencies and profit. Up to 40 percent of this cost would be for the preliminary studies phase, up to 80 percent for the design phase, and up to 10 percent would be for overseeing construction.

The total cost of a retrofit project can initially be estimated based on the projected construction costs to be incurred. Typical ranges of categorical costs to the project are:

| | | (%) |
|---|---|---|
| 1. | Estimates of Construction Costs | 100 |
| 2. | Contingencies | 10-25 |
| 3. | Engineering Costs (Basic and Special Services) | 6-18 |
| 4. | Legal and Administrative Costs | 2-3 |
| 5. | Financing Costs | 1-5 |
| 6. | Interest During Construction | 4-8 |
| | TOTAL | 123-159 |

Non-construction costs are a significant part of total project costs, but in general the larger projects would show lower proportions of such non-construction costs. Consideration must also be given to costs incurred by delays in material deliveries and construction start-times. Indices of inflationary trends are available to evaluate this impact, and can be found in Engineering News Record's Weekly Index of Construction Costs, the Handy-Whitman Index, and the BLS-Labor Cost Index.

The high cost of upgrading water treatment plants to meet the proposed regulations points out the need for available investment contingencies and economizing plans. The former would require a dependence on Federal revenues and Federal cost-sharing programs. Unfortunately, while Federal grants have been successful in the past in eliciting investment response for wastewater treatment facilities, that effectiveness has steadily declined. This may be an indication that grants given to the supply water industry should be based on a priority basis, with funds directed to the most useful projects first. In addition, the states would be responsible for a share of the costs of upgrading. Wherever possible, the states would have to utilize their own personnel for monitoring, engineering, design, and general implementation of the projects necessary to insure that regulations are met.

It may well be necessary for several communities in the same locale to coordinate their implementation efforts in order to save money. Many water supply systems might be able to retain professional engineering services and construction services under a single multi-community contract at a substantial savings to each. While regional efforts to establish coordinated river basin organizations for the purpose of managing water supply quality are not presently in wide usage, such organizations have great theoretical advantages and may be worth further exploration.

# APPENDIX J

# REVISED DRINKING WATER STANDARDS

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## PART 141—NATIONAL INTERIM PRIMARY DRINKING WATER ~~STANDARDS~~ REGULATIONS

### Subpart A - Maximum Contaminant Levels

Sec.
141.1 Applicability.
141.2 Definitions.
141.3 Coverage.
141.11 Maximum contaminant levels for inorganic chemicals.
141.12 Maximum contaminant levels for organic chemicals.
~~141.13 Maximum contaminant levels for pesticides.~~
~~141.14~~ 141.13 Maximum contaminant levels for turbidity.
~~141.15~~ 141.14 Maximum microbiological contaminant levels.
~~141.16~~ 141.15 Substitution of residual chlorine measurement for total coliform measurement.
141.21 Microbiological contaminant sampling and analytical requirements.
141.22 Turbidity sampling and analytical requirements.
141.23 Inorganic chemical sampling and analytical requirements.
141.24 Pesticide and organic chemicals sampling and analytical requirements.
~~141.25~~ Laboratory certification.
141.27 Alternative analytical techniques.
141.28
141.29 Monitoring consecutive public water systems.
141.31 Reporting requirements.
141.32 Public notification of variances, exemptions and non-compliance with standards.
141.33 Record Maintenance
141.34 Variances and Exemptions.
141.41 Siting requirements.
141.51 Effective date.

AUTHORITY: Secs. 1412, ~~1414~~, ~~1415~~, 1445 and 1450 of Pub. L. 93-523.

**§ 141.1 Applicability.**

This subpart sets forth the interim primary drinking water ~~standards~~ regulations required by section 1412 of the Public Health Service Act, as amended by the Safe Drinking Water Act (Pub. L. 93-523).

**§ 141.2 Definitions.**

As used in this ~~subpart~~ PART the term:

(a) "Act" means the Public Health Service Act, as amended by the Safe Drinking Water Act, Pub. L. 93-523.

~~(b) "Community water system" means a public water system which serves a population of which 70 percent or greater are residents.~~

(b) "Community water system" means a public water system which has at least fifteen service connections or serves a non-transient population. The term includes public water systems providing water to residential communities, schools, factories, office buildings and other facilities in which the same 25 or more people regularly consume the drinking water. The term does not include public water systems which provide water only to gas stations, restaurants, campgrounds and those which are carriers which convey passengers in interstate commerce.

(c) "Contaminant" means any physical, chemical, biological, or radiological substance or matter in water.

2.

**(d)** "Maximum contaminant level" means the maximum permissible level of a contaminant in water which is delivered to the ~~free-flowing outlet~~ of the ultimate user of a public water system.

Service connection

**(e)** "Person" means an individual, corporation, company, association, partnership, State, municipality, or Federal agency.

It is anticipated that a portion of the samples will be taken from the consumers taps.

**(f)** "Public water system" means a system for the provision to the public of piped water for human consumption, if such system has at least fifteen service connections or regularly serves an average of at least twenty-five individuals daily at least ~~three~~ months out of the year. Such term includes (1) any collection, treatment, storage, and distribution facilities under control of the operator of such system and used primarily in connection with such system, and (2) any collection or pretreatment storage facilities not under such control which are used primarily in connection with such system.

two

**(g)** "State" means the agency of the State government which has jurisdiction over public water systems. During any period when a State does not have primary enforcement responsibility, the term 'State' means the Regional Administrator, Environmental Protection Agency.

**(h)** "Supplier of water" means any person who owns or operates a public water system.

### § 141.3 Coverage.

The interim primary drinking water ~~standards~~ under this subpart shall apply to each public water system in a State, except that such standards shall not apply to a public water system which—

regulations

regulations

(a) Consists only of distribution and storage facilities (and does not have any collection and treatment facilities);

(b) Obtains all of its water from, but is not owned or operated by, a public water system to which such regulations apply;

(c) Does not sell water to any person; and

(d) Is not a carrier which conveys passengers in interstate commerce.

### § 141.11 Maximum contaminant levels for inorganic chemicals.

(a) The following are the maximum contaminant levels for inorganic chemicals:

| Contaminant: | Level (mg/l) |
|---|---|
| Arsenic | 0.05 |
| Barium | 1. |
| Cadmium | 0.010 |
| Chromium | 0.05 |
| Cyanide | 0.2 |
| Lead | 0.05 |
| Mercury | 0.002 |
| Nitrate (as N) | 10. |
| Selenium | 0.01 |
| Silver | 0.05 |

(b) When the annual average of the maximum daily air temperatures for the location in which the public water system is situated is the following, the corresponding concentration of fluoride shall not be exceeded:

| Temperature (in F°) | (C°) | Level (mg/l) |
|---|---|---|
| 50.0 to 53.7 | 10.0 to 12.0 | 2.4 |
| 53.8 to 58.3 | 12.1 to 14.6 | 2.2 |
| 58.4 to 63.8 | 14.7 to 17.6 | 2.0 |
| 63.9 to 70.6 | 17.7 to 21.4 | 1.8 |
| 70.7 to 79.2 | 21.5 to 26.2 | 1.6 |
| 79.3 to 90.5 | 26.3 to 32.5 | 1.4 |

The requirements of this paragraph (b) do not apply to public water supplies serving only educational institutions.

### ~~§ 141.12 Maximum contaminant levels for organic chemicals.~~

~~The maximum contaminant level for the total concentration of organic chemicals, as determined by the carbon chloroform extract method set forth in § 141.24(b), is 0.7 mg/l.~~

### § ~~141.13~~ Maximum contaminant levels for ~~pesticides.~~

141.12
organic chemicals.

The following are the maximum contaminant levels for ~~pesticides:~~

organic chemicals:

(a) Chlorinated Hydrocarbons:

| | Level mg/l |
|---|---|
| Chlordane (cis and trans) (1,2,4,5,-6,7,8,8 - Octachloro - 3a,4,5,7a-tetrahydro-4,7-methanoindan) | 0.003 |
| Endrin (1,2,3,4,10,10 - Hexachloro-6,7 - epoxy - 1,4,4a,5,6,7,8,8a-octahydro-1,4-endo, endo-5,8-dimethano naphthalene) | 0.0002 |
| Heptachlor (1,4,5,6,7,8,8-Heptachloro-3a,4,7,7a-tetrahydro 4,7-methanoindene) | 0.0001 |
| Heptochlor Epoxide (1,4,5,6,7,8,8-Heptachloro - 2,3-epoxy-3a,4,7,7a-tetrahydro-4,7-methanoindan) | 0.0001 |
| Lindane (1,2,3,4,5,6-Hexachlorocyclohexane, gamma isomer) | 0.004 |
| Methoxychlor (1,1,1-Trichloro-2,2-bis [p-methoxyphenyl] ethane) | 0.1 |
| Toxaphene ($C_{10}H_{10}Cl_8$—Technical chlorinated camphene, 67-69% chlorine) | 0.005 |

(b) Chlorophenoxys:

| | |
|---|---|
| 2,4-D (2,4-Dichlorophenoxyacetic acid) | 0.1 |
| 2,4,5-TP Silvex (2,4,5-Trichlorophenoxypropionic acid) | 0.01 |

### § ~~141.14~~ Maximum contaminant level of turbidity.

141.13

The maximum contaminant level of turbidity in the drinking water at a representative entry point(s) to the distribution system is one turbidity unit (TU), as determined pursuant to § 141.22, except that five or fewer turbidity units may be allowed if the supplier of water can demonstrate to the State that the higher turbidity does not:

(a) Interfere with disinfection;

(b) Prevent maintenance of an effective disinfectant agent throughout the distribution system; and

(c) Interfere with microbiological determinations.

### § ~~141.15~~ Maximum microbiological contaminant levels.

141.14

~~(a)~~ The supplier of water may employ one of the following ~~two methods to determine~~ compliance with the coliform maximum contaminant levels:

(a) ~~(1)~~ When the supplier of water employs tho membrane filter technique pursuant to § 141.21(a) the coliform densities shall not exceed one per 100 milliliters as the arithmetic mean of all samples examined per month; and either

(1) ~~(i)~~ Four per 100 milliliters in more than one standard sample when less than 20 are examined per month; or

(2) ~~(ii)~~ Four per 100 milliliters in more than five percent of the standard samples when 20 or more are examined per month.

(b) (1) ~~(2)(i)~~ When the supplier of water employs the fermentation tube method and 10 milliliter standard portions pursuant to § 141.21, coliforms shall not be present in more than 10 percent of the portions in any month; and either

(i) ~~(A)~~ Three or more portions in more than one sample when less than 20 samples are examined per month; or

(ii) ~~(B)~~ Three or more portions in more than five percent of the samples if 20 or more samples are examined per month.

(2) ~~(ii)~~ When the supplier of water employs the fermentation tube method and 100 milliliter standard portions pursuant to § 141.21(a) coliforms shall not be present in more than 60 percent of the portions in any month; and either

(i) ~~(A)~~ Five or more portions in more than one sample when less than five samples are examined; or

(ii) ~~(B)~~ Five or more portions in more than 20 percent of the samples when five samples or more are examined.

~~(b) The supplier of water shall provide water in which there shall be no greater than 500 organisms per one milliliter as determined by the standard bacterial plate count provided in § 141.21(f).~~

**§ 141.16 Substitution of residual chlorine measurement for total coliform measurement.**

(a) The ~~supplier of water~~ supplier of water (stet) may, with the approval of the State and based upon a sanitary survey, substitute the use of chlorine residual monitoring for not more than 75 percent of the samples required to be taken by § 141.21(b), provided that the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the frequency of at least four for each substituted microbiological sample. There shall be at least daily determinations of chlorine residual. Measurements shall be made in accordance with "Standard Methods," 13th Ed., pp 129-132. When the supplier of water exercises the option provided in this paragraph (a), he shall maintain no less than 0.2 mg/l free chlorine in the public water distribution system.

~~(b) For public water systems serving 4900 or fewer persons, the supplier may, with the approval of the State, make a total substitution of chlorine residual measurement for the samples required to be taken by § 141.21(b): *Provided*, That the supplier of water takes chlorine residual samples at points which are representative of the conditions within the distribution system at the rate of one per day for each microbiological sample required to be taken per month under~~

~~§ 141.21. When the supplier of water exercises the option provided by this paragraph (b) he shall maintain no less than 0.3 mg/l free chlorine in the public water distribution system. Measurements shall be made in accordance with "Standard Methods," 13th Ed., pp 129-132.~~

## § 141.21 Microbiological contaminant sampling and analytical requirements.

(a) The ~~supplier of water~~ shall make coliform density measurements, for the purpose of determining compliance with § ~~141.15~~, in accordance with the analytical recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 13th Edition, pp 662-688, except that only a 100 milliliter sample size shall be employed in the membrane filter technique. The samples shall be taken at points which are representative of the conditions within the distribution system.

operator of a community water system

141.14

(b) The ~~supplier of water~~ shall take coliform density samples at regular intervals throughout the month, and in number proportionate to the population served by the public water system. In no event shall the frequency be less than as set forth below:

operator of a community water system

| *Population served:* | *Minimum number of samples per month* |
|---|---|
| ~~25 to 2,500~~ | 2 |
| 2,501 to 3,300 | 3 |
| 3,301 to 4,100 | 4 |
| 4,101 to 4,900 | 5 |
| 4,901 to 5,800 | 6 |
| 5,801 to 6,700 | 7 |
| 6,701 to 7,600 | 8 |
| 7,601 to 8,500 | 9 |
| 8,501 to 9,400 | 10 |
| 9,401 to 10,300 | 11 |
| 10,301 to 11,100 | 12 |
| 11,101 to 12,000 | 13 |
| 12,001 to 12,900 | 14 |
| 12,901 to 13,700 | 15 |
| 13,701 to 14,600 | 16 |
| 14,601 to 15,500 | 17 |
| 15,501 to 16,300 | 18 |
| 16,301 to 17,200 | 19 |
| 17,201 to 18,100 | 20 |
| 18,101 to 18,900 | 21 |
| 18,901 to 19,800 | 22 |
| 19,801 to 20,700 | 23 |
| 20,701 to 21,500 | 24 |
| 21,501 to 22,300 | 25 |
| 22,301 to 23,200 | 26 |
| 23,201 to 24,000 | 27 |
| 24,001 to 24,900 | 28 |
| 24,901 to 25,000 | 29 |
| 25,001 to 28,000 | 30 |
| 28,001 to 33,000 | 35 |
| 33,001 to 37,000 | 40 |
| 37,001 to 41,000 | 45 |
| 41,001 to 46,000 | 50 |
| 46,001 to 50,000 | 55 |
| 50,001 to 54,000 | 60 |
| 54,001 to 59,000 | 65 |
| 59,001 to 64,000 | 70 |
| 64,001 to 70,000 | 75 |
| 70,001 to 76,000 | 80 |
| 76,001 to 83,000 | 85 |
| 83,001 to 90,000 | 90 |
| 90,001 to 96,000 | 95 |
| 96,001 to 111,000 | 100 |
| 111,001 to 130,000 | 110 |
| 130,001 to 160,000 | 120 |
| 160,001 to 190,000 | 130 |
| 190,001 to 220,000 | 140 |
| 220,001 to 250,000 | 150 |
| 250,001 to 290,000 | 160 |
| 290,001 to 320,000 | 170 |

25 to 1000

1001

| Population served: | Minimum number of samples per month |
|---|---|
| 320,001 to 360,000 | 180 |
| 360,001 to 410,000 | 190 |
| 410,001 to 450,000 | 200 |
| 450,001 to 500,000 | 210 |
| 500,001 to 550,000 | 220 |
| 550,001 to 600,000 | 230 |
| 600,001 to 660,000 | 240 |
| 660,001 to 720,000 | 250 |
| 720,001 to 780,000 | 260 |
| 780,000 to 840,000 | 270 |
| 840,001 to 910,000 | 280 |
| 910,001 to 970,000 | 290 |
| 970,001 to 1,050,000 | 300 |
| 1,050,001 to 1,140,000 | 310 |
| 1,140,001 to 1,230,000 | 320 |
| 1,230,001 to 1,320,000 | 330 |
| 1,320,001 to 1,420,000 | 340 |
| 1,420,001 to 1,520,000 | 350 |
| 1,520,001 to 1,630,000 | 360 |
| 1,630,001 to 1,730,000 | 370 |
| 1,730,001 to 1,850,000 | 380 |
| 1,850,001 to 1,970,000 | 390 |
| 1,970,001 to 2,060,000 | 400 |
| 2,060,001 to 2,270,000 | 410 |
| 2,270,001 to 2,510,000 | 420 |
| 2,510,001 to 2,750,000 | 430 |
| 2,750,001 to 3,020,000 | 440 |
| 3,020,001 to 3,320,000 | 450 |
| 3,320,001 to 3,620,000 | 460 |
| 3,620,001 to 3,960,000 | 470 |
| 3,960,001 to 4,310,000 | 480 |
| 4,310,001 to 4,690,000 | 490 |
| ≥4,690,000 | 500 |

(c) For public water systems other than community water systems, the State shall establish minimum sampling frequencies. In prescribing the number of samples to be taken, the State shall consider, among other factors, the nature and type of the water source, historical data characterizing the water quality, vulnerability of the source to accidental or deliberate contamination, the population served by the system, the type of treatment provided by the system, and the level of the microbiological contaminant which is generally found.

~~(c)~~ (1) When the coliform colonies in a single standard sample exceed four per 100 milliliters (§ ~~141.15(a)(1)~~), daily samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show less than one coliform per 100 milliliters.

(d)

141.14 (a)

(2) When organisms of the coliform group occur in three or more 10 ml portions of a single standard sample (§ ~~141.15(a)(2)(i)~~), daily samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show no positive tubes.

141.14(b)(1)

(3) When organisms of the coliform group occur in all five of the 100 ml portions of a single standard sample (§ ~~141.15~~(a)(2)(ii)), daily samples shall be collected and examined from the same sampling point until the results obtained from at least two consecutive samples show no positive tubes.

141.14 (b)(2)

(4) The location at which the check sample was taken pursuant to paragraphs ~~(c)~~ (1), (2) or (3) of this section must not be eliminated from future sampling because of a history of questionable water quality. Check samples shall not be included in calculating the total number of samples taken each month to determine compliance with § ~~141.15~~.

(d)

141.14

~~(d)~~ When a particular sampling point has been confirmed, by the first check sample examined as directed in paragraphs ~~(c)~~ (1), (2), or (3) of this section, to be in non-compliance with the maximum contaminant levels set forth in § 141.15, the supplier of water shall notify the State as prescribed in § 141.31.

(e)

(d)

141.14

~~(e)~~ When the maximum contaminant levels set forth in paragraphs (a) ~~(1)~~ or ~~(2)~~ of § ~~141.15~~ are exceeded as confirmed by check samples taken pursuant to paragraphs ~~(c)~~ (1), (2), or (3) of this sec-

(f)

(b)

141.14

(d)

the supplier of water shall report as directed in § 141.32(a) or(b).

(g)

141.15

When a particular sampling point has been shown to be in non-compliance with the requirements of § ~~141.14~~, water from that location shall be retested within one hour. If the non-compliance is confirmed, the State shall be notified as prescribed in § 141.31. Also, if the non-compliance is confirmed, a sample for coliform analysis must be immediately collected from that sampling point and the results of such analysis reported to the State.

~~(g) Standard bacteria plate count samples shall be analyzed in accordance with the recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 13th Edition, pp 660-662. Samples taken for the purpose of plate count analysis shall be collected at points which are representative of conditions within the distribution system at a frequency at least equal to 10 percent of the frequency for coliform analysis as directed in paragraph (b) of this section with the exception that at least one sample shall be collected and analyzed monthly.~~

## § 141.22 Turbidity sampling and analytical requirements.

(a) Samples shall be taken at a representative entry point(s) to the water distribution system at least once per day (at least once per month for supplies using water obtained from underground sources) for the purpose of making turbidity measurements to determine compliance with § ~~141.13~~. The measurement shall be made in accordance with the recommendations set forth in "Standard Methods for the Examination of Water and Wastewater," American Public Health Association, 13th Edition, pp. 350-353 (Nephelometric Method).

(b) In the event that such measurement indicates that the maximum allowable limit has been exceeded, the sampling and measurement shall be repeated within one hour. The results of the two measurements shall be averaged, and if the average confirms that the maximum allowable limit has been exceeded, this average shall be reported as directed in § 141.31. If the monthly average of all samples exceeds the maximum allowable limit, this fact shall be reported as directed in § 141.32(a) or(b).

(c) The requirements of this § 141.22 shall ~~not~~ apply to public water systems ~~other than~~ community water systems

and

which use water obtained from underground sources.

## § 141.23 Inorganic chemical sampling and analytical requirements.

(a) ~~(1)~~ To establish an initial record of water quality, an analysis of substances for the purpose of determining compliance with § 141.11 ~~shall be completed for all~~ community water systems utilizing surface water sources within one year following the effective date of this subpart. This analysis shall be repeated at yearly intervals.

(2) Analyses for community water systems utilizing ground water sources

141.13

or if the average of two consecutive samples taken 1 hr. apart exceeds 5 TU,

which are not

only

For community water systems which use water only obtained from underground sources, the State may modify the sampling frequency requirements of subparagraph (a) of this section 141.22. In prescribing the number of samples to be taken, the State shall consider, among other factors, the nature and type of the water source, historical data characterizing the water qulaity, anticipated variations in water quality, vulnerability of the source to accidental or deliberate contamination, the population served by the system, the type of treatment provided by the system, the level of turbidity contamination which is generally found, and the costs of monitoring and analysis.

(1) For all

shall be completed

shall be completed within two years following the effective date of this subpart. This analysis shall be repeated at three-year intervals.

(3) ~~Analyses~~ For public water systems other than community water systems, whether supplied by surface or ground water sources, shall be completed within six years following the effective date of this subpart. These analyses shall be repeated at five-year intervals.

include only requirement for nitrates, otherwise - not health effect.

~~(b) If the supplier of water determines or has been informed by the State that the level of any contaminant is 75 percent or more of the maximum contaminant level, he shall analyze for the presence and quantity of that contaminant at least once per month following the initial analysis or information. If, after conducting monthly testing for a period of at least one year, the supplier of water demonstrates to the satisfaction of the State that the level of such contaminant is stable and due to a natural condition of the water source, he may reduce the frequency of analysis for that contaminant consistent with the requirements of paragraph (a) of this section.~~

(6)

~~(c)~~ If the supplier of water determines or has been informed by the State that the level of any contaminant listed in § 141.11 exceeds the maximum contaminant level for the substance, he shall confirm such determination or information by repeating the analysis within 24 hours following the initial analysis or information, and then at least at weekly intervals ~~during the period of time the maximum contaminant level for that substance has been exceeded~~, or until a monitoring schedule as a condition to a variance, exemption or enforcement action shall become effective. The results of such repetitive testing shall be averaged and reported as prescribed in paragraph (d) of this section.

until the maximum contaminant level is not exceeded in samples taken on two successive weeks,

, whichever occurs first.

(c)

~~(d)~~ To judge the compliance of a public water system with the maximum contaminant levels listed in § 141.11, averages of data shall be used and shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question. Each average shall be calculated on a past 12-month moving average basis if less than twelve samples per year are analyzed, and on a past three month moving average basis if twelve or more samples per year are analyzed. In cases where the maximum contaminant level has been exceeded in any one sample, the average concentration shall be calculated on a one-month moving average basis and reported pursuant to § 141.31. If the mean of the samples comprising the one month moving average exceeds the maximum contaminant level, the supplier of water shall give public notice pursuant to § 141.32(a) or (b).

(d)

~~(e)~~ The provisions of paragraphs (c) and (d) of this section notwithstanding, compliance with the maximum contaminant level for nitrate shall be determined on the basis of individual analyses rather than by averages. When a level exceeding the maximum contaminant level for nitrate is found, the analyses shall be repeated within 24 hours, and if the mean of the two analyses exceeds the maximum contaminant level, the supplier of water shall report his findings pursuant to §§ 141.31 and 141.32(a).

(f) Analyses conducted to determine compliance with § 141.11 shall be made in accordance with the following methods:

(1) Arsenic—Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 95–96, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(2) Barium—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 97–98, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(3) Cadmium—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 101–103, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(4) Chromium—Atomic Absorption Method, "Standard Methods for the Examination of water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 105–106, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(5) Cyanide—Titration or Colorimetric Methods, "Methods for Chemical Analysis of Water and Wastes," pp. 40–48, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(6) Lead—Atomic Absorption Method, "Standards Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," pp. 112–113, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(7) Mercury—Flameless Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," pp. 118–126, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(8) Nitrate—Brucine Colorimetric Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 461–464, or Cadmium Reduction Method, "Methods for Chemical Analysis of Water and Wastes," pp. 201–206, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(9) Selenium—Atomic Absorption Method, "Methods for Chemical Analysis of Water and Wastes," p. 145, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(10) Silver—Atomic Absorption Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 210–215, or "Methods for Chemical Analysis of Water and Wastes," p. 146, Environmental Protec-

tion Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

(11) Fluoride—Electrode Method, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 172–174, or "Methods for Chemical Analysis of Water and Wastes," pp. 65–67, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974, or Colorimetric Method with Preliminary Distillation, "Standard Methods for the Examination of Water and Wastewater," 13th Edition, pp. 171–172 and 174–176, or "Methods for Chemical Analysis of Water and Wastes," pp. 59–60, Environmental Protection Agency, Office of Technology Transfer, Washington, D.C. 20460, 1974.

**§ 141.24 ~~Pesticide and~~ Organic chemicals sampling and analytical requirements.**

(a) ~~(1)~~ To establish an initial record of water quality, an analysis of substances for the purpose of determining compliance with §§ 141.12 ~~and 141.13 shall be completed for all community water systems~~ utilizing surface water sources within one year following the effective date of this subpart. This analysis shall be repeated at yearly intervals.

(1) For all community water systems

shall be completed

(2) ~~An analysis~~ For community water systems utilizing ground water sources shall be completed within two years following the effective date of this subpart. This analysis shall be repeated at three-year intervals.

~~(3) Analyses for public water systems other than community water systems, whether supplied by surface or ground water sources, shall be completed within six years following the effective date of this subpart. These analyses shall be repeated at five-year intervals.~~

same rationale as inorganics - not health effect

~~(b) If the supplier of water determines or has been informed by the State that the level of any contaminant is 75 percent or more of the maximum contaminant level, he shall analyze for the presence and quantity of that contaminant at least once per month following the initial analysis or information. If, after conducting monthly testing for a period of at least one year, the supplier of water demonstrates to the satisfaction of the State that the level of such contaminant is stable and due to a natural condition of the water source, he may reduce the frequency of analysis for that contaminant consistent with the requirements of paragraph (a) of this section.~~

~~(c) If the supplier of water determines or has been informed by the State that the level of contaminants set forth in § 141.12 exceeds the maximum contaminant level, he shall confirm such determination or information by repeating the analyses within two weeks following the initial analysis or information. The average of the two analyses, if in excess of the maximum contaminant level, shall be reported as directed in §§ 141.31 and 141.32(a).~~

141.12

~~(d)~~ (b) If the supplier of water determines or has been informed by the State that the level of any contaminant listed in § ~~141.13~~ exceeds the maximum contaminant level for the substance, he shall confirm such determination or information by repeating the analysis within 24 hours following the initial analysis or information, and then at least at weekly intervals ~~during the period of time the maximum contaminant level for that substance has been exceeded~~, or until a monitoring schedule as a condition to variance, exemption or enforcement action shall become effective. The results of such repetitive testing shall be averaged and reported as prescribed in paragraph (e) of this section.

until the maximum contaminant level is not exceeded in samples taken on two successive weeks,

, whichever occurs first.

~~(e)~~ (c) To judge the compliance of a public water system with the maximum contaminant levels listed in § ~~141.13~~, 141.12 averages of data shall be used and shall be rounded to the same number of significant figures as the maximum contaminant level for the substance in question. Each average shall be calculated on a past 12-month moving average basis if less than twelve samples per year are analyzed, and on a past three month moving average basis if twelve or more samples per year are analyzed. In cases where the maximum contaminant levels of § ~~141.13~~ 141.12 have been exceeded in any one sample, the average concentration shall be calculated on a one-month moving average basis and reported pursuant to § 141.31. If the mean of the samples comprising the one month moving average exceeds the maximum contaminant level, the supplier of water shall give public notice pursuant to § 141.32(a) or (b).

~~(f) Sampling and analyses made to determine compliance with § 141.12 shall be made in accordance with "An Improved Method for Determining Organics in Water by Activated Carbon Absorption and Solvent Extraction," Parts 1 and 2, Buelow, et al., Journal of American Water Works Association, 65: 57, 197 (1973).~~

~~(g)~~ (d) Analyses made to determine compliance with § ~~141.13~~ 141.12(a) shall be made in accordance with "Method for Organochlorine Pesticides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, Ohio, November 28, 1973.

(h) Analyses made to determine compliance with § ~~141.13~~ 141.12(b) shall be conducted in accordance with "Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," MDQARL, Cincinnati, Ohio, November 23, 1973.

## 141.27 Alternative analytical techniques

With the written permission of the State, a supplier of water may employ an alternative analytical technique to those required by this subpart. An alternative technique shall be no less accurate than technique required by this subpart. The use of the alternative analytical technique shall not affect the frequency of monitoring required by this subpart.

**§ 141.27 Laboratory certification.**

For the purposes of determining compliance with §§ 141.21 through 141.24, samples may be considered only if they have been analyzed by a laboratory approved by the State. The approval shall be contingent upon maintenance of proper laboratory methods and technical competence and upon the retention for inspection at reasonable times of analytical results. Approved laboratories shall make periodic reports as required by the State.

**§ 141.31 Reporting requirements.**

The supplier of water shall report within 40 days following a test, measurement or analysis required to be made by this

141.28

141.29 Monitoring of consecutive public water systems.(new)

When a public water system provides water to another public water system, the State may allow the systems to share the responsibilities for providing safe drinking water. To the extent possible, the State may allow the system which takes the water from the source to monitor for those contaminants which, if present at all, result from contamination of at the source; and the distributive system to monitor for contaminants which, if present at all, result from contamination in the distribution system. The public water system with the responsibility for monitoring shall also have the duty to report and to notify, as required by this subpart, with respect to the contaminant for which it is monitoring.

(a)

to the State

subpart, the results of that test, measurement or analysis ~~; Provided, That the~~ supplier of water shall report within 36 hours the failure to meet any standards (including failure to comply with monitoring requirements) set forth in this subpart. ~~Reports required to be made by this § 141.31 shall be communicated to the State, except that Federal Agencies shall report to the Regional Administrator.~~

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**§ 141.32 Public notification of variances, exemptions and noncompliance with standards.**

(a) The ~~supplier of water~~ shall give notice to the persons served by the ~~public water~~ system of any failure on the part of the system to comply with the requirements (including monitoring requirements) of this subpart. The ~~supplier of water~~ shall give the notice required by this § 141.32 not less than once every three months during the life of the noncompliance:

owner or operator of a community water system

owner or operator

(1) By publication on not less than three consecutive days in a newspaper or newspapers of general circulation serving the area served by ~~such public~~ water system, which newspaper or newspapers shall be approved by the State. ~~With respect to the public water systems operated by Federal Agencies, the newspapers cited in this paragraph shall be approved by the Regional Administrator;~~

the community

(2) By furnishing a copy thereof to the radio and television stations serving such area as soon as practicable but not later than 36 hours after confirmation of the noncompliance with respect to which the notice is required; and

(3) By inclusion with the water bills of the ~~public~~ water system at least once every three months if the water bills are issued at least once every three months, and with every water bill if they are issued less often. If water bills are not issued, other means of notification acceptable to the State may be used. The notice required by this § 141.32 shall state at least that the ~~public~~ water system fails to monitor, operate the system or provide water which meets all the requirements of this subpart and shall state with particularity those requirements for which there is noncompliance. If a quantitative limitation has been exceeded, the notice shall state what the Federal or State limitation is, and at what level of performance the water supply system has been operating.

~~(b)~~ The supplier of water shall give notice pursuant to the procedures set forth in paragraph (a) of this section—

(1) When his system has received a variance under section 1415(a)(1) or 1415(a)(2) of the Act, and shall continue the notification process at no less than three month intervals during the life of the variance;

community

community

(b) The State shall require by order or regulation the owner or operator of a public water system other than a community water system to give notice to the persons served by the system of any failure on the part of the system to comply w/ the requirement (including monitoring requirements) of this subpart. The form and manner of the notice shall be such as to insure that the public using the public water system is informed that the system is performing inadequately.

(c)

and (b)

(d) Any violation requiring notification according to 141.32 shall be reported to the State and corrective action shall be immediately initiated by the supplier of water.

(2) When his system has received an exemption under section 1416 and shall continue the notification process at no less than three month intervals during the life of the exemption; or

(3) When his system has failed to comply with any schedule or control measure prescribed pursuant to a variance or exemption and shall continue the notification process at no less than the three month intervals during the life of the variance and exemption.

### § 141.41 Siting requirements.

Before a person may enter into a financial commitment for or initiate construction of a new public water system or increase the capacity of an existing public water system, he shall—

(a) To the extent practicable, avoid locating part or all of the new or expanded facility at a site which:

(1) Is subject to earthquakes, floods, fires or other man-made disasters which could cause breakdown of the public water system or a portion thereof; and

(2) Is within the floodplain of a 100 year flood;

(b) Notify the State.

### § 141.51 Effective date.

The standards set forth in this subpart shall take effect 18 months after the date of promulgation.

[FR Doc.75-6603 Filed 3-13-75;8:45 am]

141.33 Record maintenance - John Co

141.34 Variances and Exemptions - Little

One sentence only

# APPENDIX K

## DESCRIPTION OF ORIGINAL SMSA'S

The following definitions of the SMSA regions used in the original PHS study are quoted exactly as defined in that study:

Region I - State of Vermont: Vermont was included in the study at the request of the Commissioner of Health with concurrence of the Governor. (Replaced the initially selected SMSA in this Region).

Region II - New York, New York: This SMSA included Rockland, Westchester, Nassau, and Suffolk Counties in addition to the City of New York. It was selected to represent those water supplies utilizing surface-water providing disinfection only for treatment and those utilizing groundwaters from high population density areas. It also represents the highly urbanized (megapolis) areas of the United States.

Region III - Charleston, West Virginia: This SMSA included Kanawha County. It was selected to represent those supplies using surface-waters that receive the wastes from a highly industrialized area. The small coal mine town represent supplies in economically depressed areas of the northern Appalachian area.

Region IV - Charleston, South Carolina: This SMSA included Berkeley and Charleston Counties. It was selected to represent the Atlantic and Gulf coast areas using both surface- and groundwater.

Region V[1] - Cincinnati, Ohio; Kentucky; Indiana: This SMSA included Hamilton, Warren and Clermont Counties, Ohio; Boone, Campbell, and Kenton Counties, Kentucky; and Dearborn County, Indiana. It was selected to represent those portions of mid-America using surface-water receiving a considerable amount of industrial discharge in addition to municipal wastes and agricultural runoff.

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[1] Region V in original study is in EPA region VI.

Region VI[1] - Kansas City, Missouri; Kansas: This SMSA included Cass, Clay, Jackson, and Platte Counties, Missouri and Johnson and Wyandotte Counties, Kansas. It is similar to the Cincinnati SMSA, but was selected to represent surface-waters with a larger agricultural runoff to industrial waste ratio.

Region VII - New Orleans, Louisiana: This SMSA included Jefferson, Orleans, St. Bernard, and St. Tammany Parishes, Louisiana. It was selected to represent the supplies receiving surface-water drained from large and varied river basins, plus some from deep artesian wells.

Region VIII - Pueblo, Colorado: This SMSA included Pueblo County, Colorado. It was selected to represent the water supplies of the high plains region of the country that have a mixture of groundwater and surface-water sources.

Region IX - San Bernadino, Riverside, Ontario, California: This SMSA included San Bernadino and Riverside Counties, California. It was selected to represent the semi-arid regions of the west and southwest as well as an area served primarily by groundwater.

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[1] Region VI in original study is EPA region V.